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ORIGINAL ARTICLES.

I.—The Earliest Traces of Man.[1]

By Sir Henry H. Howorth, K.C.I.E., F.R.S., F.G.S.

THE origin of Man remains an unsolved problem. In spite of very keen and anxious researches, extending over many years, we are still without a real clue to the difficulty. Whence and how and when he came we do not know, and we had better say so.

In the valley of the Nile, where the earliest knowledge of writing has been traced, our written records take us back perhaps 7,000 years. At that period the various races and varieties into which the human race is divided by the naturalist were apparently completely differentiated. The different families of language which the philologer has discriminated were sharply defined, while his thought and the products of his thought (of which language is an index), of comparative archæology, mythology, etc., etc., show that these races were as trenchantly distinguished as they are now.

Whatever else this means it must mean (if the history of mankind has been continuous) that the origin of man is a long way off, a much longer way off than people were once willing to admit. The differences and distinctions here pointed out must have taken a very long time to mature, and if man originated in one stock, which has overspread and conquered the earth, as some of us think, it must have taken a vast time for the many languages, religions, customs, and thoughts, which characterize his many and varied clans and tribes and nations, to diverge so much from each other.

It may be that presently with the assistance of comparative methods applied scientifically to language, religion, and art, we may be able to disentangle the crooked threads into which the web of human progress has been woven; but this must take a long time. It will involve a wide and searching analysis of difficult details,

[1] "Palæolithic Man in Africa," by Sir John Evans, K.C.B., F.R.S.: Proc. Roy. Soc., 1900, vol. lxvi.

"Eolithic Implements," by Rev. R. Ashington Bullen, B.A., F.L.S., F.G.S.: Trans. Vict. Inst., 1900.

"A Collection of Stone Implements in the Mayer Museum," by H. O. Forbes, LL.D.: Bull. Liverpool Mus., 1900, ii.

"The Age of the Surface Flint Implements of Egypt and Somaliland," by H. O. Forbes, LL.D.: Bull. Liverpool Mus., 1901, iii.

and will probably depend a good deal more on the ethnographer and the linguist than on the archæologist.

With that great problem we have not at present to do, however. If we are to make any progress at all we must limit it very considerably, and detach ourselves completely from such ambitious issues as the origin of Man, etc., etc., as we must from all attempts at surveying the universe from China to Peru. Our geographical as well as our archæological frontiers must be sharply limited.

Let us for a few paragraphs, therefore, limit ourselves to a smaller area and narrower conditions, and try to realize what we have been able to learn of the oldest inhabitants of the European area. It will readily be seen that the problem means that we must summon the geologist to our help. The problem is, in fact, as much a geological as it is an archæological one. It depends for its solution quite as much upon clearly distinguishing the geological horizon where the test object is found as upon the character and appearance of the object itself. If an object is found in an undisturbed bed of sand, gravel, or clay, it must if thus *in sitû* be as old as the laying down of the bed in question, and that is a geological problem.

The first step taken in answering the question we are discussing was a long time ago. In 1713 an implement made of black flint and of the type now known as Palæolithic was discovered with the tooth of an elephant in digging gravel in Grays Inn Lane. This implement was distinctly recognized as of human workmanship, and was presented to the British Museum, in which collection it has since remained.

In the catalogue of the Sloane Collection we find the following entry in regard to this very famous relic:—"*No.* 246, *a British weapon found, with elephant's teeth, opposite to black St. Mary's near Grayes Inn Lane* (*Conyers*). *It is a large black flint shaped into the figure of a spear point* (*K.*)." It appears, says Sir John Evans, to have been found at the close of the seventeenth century, and a rude engraving of it illustrates a letter on the antiquities of London, by Mr. Bagford, in 1715, and printed in Hearne's edition of Leland's "Collectanea," I, lxiv. From his account it would seem that the skeleton of an elephant was found not far from Battlebridge by Mr. Conyers, and that near the place where it was found "a British weapon made of a flint lance, like unto the head of a spear, was dug out" (Evans, "Stone Implements," 2nd ed., pp. 582–3). Sir J. Evans gives a full-sized illustration of this very interesting implement. The importance of this discovery was not recognized. Neither the geological position of the gravels in the Thames Valley nor the fact of the elephant in question having been an extinct animal could then be known or appreciated, and the discovery was doubtless treated as in no sense an extraordinary one from the archæological side.

The next recorded step taken in this inquiry was also made in Britain, namely, the discovery by John Frere in 1797 of three flint implements of the same type in the beds at Hoxne in Suffolk, which have since become so famous, and in company with bones of great

size. The objects in question were found twelve feet deep in the ground, and Frere, who clearly discriminated them as of human workmanship, says of them, "I think they are evidently weapons of war, fabricated and used by a people who had not the use of the metals" (*Archæologia*, xiii, 103). This statement was the first one in which the position was maintained by a scientific person that man had passed through a stage of culture in which he used stone only for his tools and weapons, and when he was still ignorant of the use of metals. Beyond this Frere could not of course go. The key to the whole position was not yet available. What it is very important to remember is, that long before the question was sophisticated by discussions about the antiquity or origin of man, and when it was a mere question of discriminating early specimens of human workmanship, these flint objects from the gravels of the Thames and the so-called diluvial beds of Suffolk were distinctly recognized as having been made by human hands.

The key necessary to unlock the next difficulty in the progress of discovery was produced by Cuvier in 1813, when he showed that the remains of elephants and other great beasts found in the superficial beds belong to species no longer living.

This conclusion ought to have been followed by its natural corollary, namely, its application to the discoveries already mentioned, and the admission that man was contemporaneous with the extinct animals; but the geology of the surface beds (since known as Post-Tertiary and Pleistocene) was still an unexplored province of that science; the discoveries in question were buried and forgotten, and Cuvier, whose researches had been almost entirely confined to the Tertiary beds, where he had chiefly to do with a fauna all of which had passed away, not unnaturally adopted a sceptical attitude in regard to man having lived with animals now extinct. He had met with no examples of the kind himself, and naturally appealed to other explanations when evidence to the contrary which seemed ambiguous was produced.

Such evidence was, in fact, forthcoming in 1823, when Ami Boué brought before the same great anatomist the discovery of some human bones found in the widespread loamy deposit of the Rhine Valley known as loess or lehm. This discovery was made near Lahr. (See *Annales des Sciences Naturelles*, 1829–50.)

When this discovery was brought before Cuvier he refused to accept its testimony. Discussing it in 1831 ("Discours sur les révolutions du globe," p. 29), he says, "Toute porte a croire, que l'espèce humaine n'existait point dans les pays où se découvrent les ossemens fossiles, à l'époque des révolutions qui ont enfoui ces os." It can well be believed that such a pronouncement from such a source largely dominated European opinion on the subject, for Cuvier's authority was naturally paramount.

Tournal, in a communication addressed to the *Annales des Sciences Naturelles* in October, 1828, says of the caverns at Bize, near Narbonne, "human bones occur in the same beds as the bones of extinct animals, and both exhibit the same chemical and organic

characters," and he urges that the existence of actually fossil human remains must be treated as a question in suspense. Inasmuch, however, as Tournal tells us that with the human bones were found pottery and modern marine shells, it would seem that the remains must in part, if not altogether, have belonged to so-called Neolithic times. (See *Annales des Sciences*, vol. xv, pp. 348–350.)

In 1829 M. Tournal communicated to this publication further remarks on the same subject. In this letter he refers to the researches of M. Christol, and says they were both agreed that the existence of man was not separated from that of the extinct animals, but they had been contemporaries. He says that M. Christol had shown him the human bones which he had found in the department of the Gard, i.e. in the caves of Sauvignargues, Poudres, etc., and that it was impossible to distinguish their condition from that of the bones of tigers, lions, and hyænas found with them. Their physical and chemical condition was the same, and they were found in the same beds; while in regard to the bones of some of the extinct animals he had himself found in the caverns of Bize, they bore the character of having been cut by human weapons. (Id., vol. xviii, pp. 142 seq.)

These remarks fell upon deaf ears, and the long and dreary process of sapping and undermining the prejudices of the dominant school of geologists had to be pressed for many a long year before the position was stormed. The two most effective workers in this field both died without their conclusions being accepted. One of them, who spent his life and his fortune in exploring the caves of Belgium and died broken-hearted, was Schmerling. The other, a Roman Catholic clergyman called McEnery, did corresponding work at Kents Hole. In each case the explorer claimed to have shown from evidence that was irreproachable that man had lived contemporaneously with the extinct beasts, and had left his remains mingled with theirs in the red earth beneath the stalagmite floors of the caverns.

It must not be forgotten that the person who persistently in England refused to accept the conclusion of the contemporaneity of man and the extinct beasts, and who caused McEnery's now famous memoir to be locked up at the Royal Society for years after his death, was Huxley, while Owen's views on the matter were much more enlightened.

Meanwhile, M. Boucher de Perthes, an antiquary at Abbeville, became convinced, after years of patient search, that implements of human workmanship occurred in the undisturbed gravels of the Somme Valley, and must date from the time when those gravels were deposited. He had preached for years in vain, when fortunately a great English palæontologist, the late Dr. Falconer, passed that way and was persuaded by the evidence he saw that M. Boucher de Perthes was right, and he eventually persuaded Professor Prestwich, Sir John Evans, and Sir John Lubbock to visit Abbeville and Amiens and to explore and report upon the facts. The result of their labours was embodied in a famous memoir in the *Philosophical*

Transactions. This made the position so clear and patent that the pendulum, which had been obstinately pointed to the recency of man, swayed right over, and the great mass of scientific men accepted what they had previously refused to credit.

It must be remembered by all those who turn to this famous memoir that its authors proved nothing whatever new. Their conclusions were those which had been arrived at by Tournal and Christol, by Schmerling and McEnery, long before. They merely stamped with a kind of official sanction what ought to have been generally received before.

The memoir in question, however, gave a great impetus to the inquiry about early man in Europe, and the credit of the next step in the enquiry is due to Lord Avebury (then Sir John Lubbock) and Professor Dawkins. It was Professor Dawkins, I believe, who first definitely showed that there was a gap in the history of early man, which was indexed and measured by a very important palæontological fact, namely, that of the separate coexistence of man with extinct animals and his coexistence with domesticated animals, the remains of the two sets of beasts never overlapping so far as we know. This remains the real touchstone separating the earliest known men in Europe from their successors.

Sir John Lubbock completed Professor Dawkins' distinction by giving a special name to each section of early man. The men who lived with the extinct beasts and used roughly chipped tools and weapons he styled Palæolithic, while those who used finely chipped or polished weapons and tools and had domesticated animals he called Neolithic.

After this mapping of the general problem a vast deal of work was done in many countries defining the geographical area where Palæolithic man lived, and describing his mode of life and surroundings, and among those who worked most assiduously in this behalf none have earned our gratitude more than Messrs. Christy and Lartet.

A great problem still remained to be solved, which involves a polemic, though one in which the strugglers on the old platform are becoming fewer and fewer. This is the question whether Palæolithic man lived before or after the distribution of the Drift; on this question I have myself written a good deal, and in a large work to be shortly published have tried to condense a vast mass of evidence justifying those geologists, and I believe they are now the large majority, who hold that Palæolithic man lived before the distribution of the Drift, and that the great gap, which is recognized by everyone, between Palæolithic and Neolithic man is coincident with that distribution and in all probability connected with it.

In quite recent years a further step has been taken which I believe will be eventually justified. The period before the Drift, which is specially marked by the presence of two elephants — *E. antiquus* and *primigenius* — was, I believe, perfectly continuous with that known as the Forest Bed, and marked by the presence of a special fossil elephant known as *E. meridionalis*. The two were, I believe,

simply phases of one continuous period. It would not, therefore, be *prima facie* improbable if the remains of Palæolithic man should be found in the Forest Bed.

Such remains are claimed to have been found at that horizon in Norfolk by Mr. Abbott and Mr. Savin, in Dorsetshire by Dr. Blackmore, and they have been also reported from the same horizon at St. Prest in France and in the Val d'Arno, north of Italy, in each case the remains of human workmanship being accompanied by those of *E. meridionalis*. I believe these finds are quite genuine. They are what we should *prima facie* have expected, and so far as we know they are the earliest remains of man hitherto found.

So far there is a fairly general agreement among geologists and archæologists in regard to the evidence about primitive man. At this point, however, a clear divergence must be recognized. A small and pertinacious body of inquirers, including especially Mr. B. Harrison, Mr. W. J. Lewis, and the Rev. R. A. Bullen, have in season and out of season insisted that traces of human workmanship have been discovered at a much earlier horizon in the form of very rude flint implements which have been found in the so-called plateau gravels of Southern England. To these implements the name of eoliths has been given, and the champions of their age and authenticity number among them no less important persons than Professor Prestwich and Professor Rupert Jones. They have failed, however, to secure the countenance of a large number of sceptical critics, among whom I confess I find myself. I have seen many hundreds of these eoliths, but I have seen very few which seem to me to have any purpose or motive of any kind in their shape or construction. This was fully admitted by Prestwich, who confessed that the number of these stones which showed any rational purpose in their shape was a very small percentage indeed, and surely this ought to be the first and prime necessity in attributing them to human handiwork. It was this special feature in the palæoliths of the river gravels and the caves which made men first assign them to human handiwork. How can this same conclusion be applied to thousands of shapeless stones, whose irregular outlines defy all classification? The champions of the stones fall back upon a class of tools whose shape need not be very precise, and to read their lucubrations one would suppose that the men and women who used these eoliths were engaged from January to December in nothing else but scraping skins. Some have, in fact, suggested that they did nothing else than scrape their own skins, and that the eoliths performed the double function of strygils and vermin-killers! There are no arrow-heads amongst these stones, no lances, no tools such as we are accustomed to find among recognized palæoliths.

What we do find, and what needs explanation, is a large number of once angular flints whose angles have been rubbed down by trituration, probably in a stream, and whose edges have been snipped all round their sinuous outlines. This snipping seems to be the only reasonable ground for attributing them to human hands. I am

bound to say it appears to me a very crude and remote reason upon which to base such a stupendous hypothesis.

Apart from the characters of the stones themselves, there is the difficulty of their geological age. In the book already referred to which I am about to publish, the age of the southern gravels will, among other things, be discussed. I have ventured to argue in it once again that these plateau gravels, as now distributed, were not the result of diurnal causes, fluviatile or otherwise, but of the same general cause which laid down the great mass of the drift and which acted independently of the contour of the country. I cannot, therefore, see in these gravels any traces of that vast lapse of time postulated by the champions of the human origin of the eoliths, and on the supposition that they were of vastly greater age than palæoliths.

We must remember another fact, namely, that the types we style Palæolithic, which are well marked, can now, as we have seen, be traced back to the horizon of the Forest Bed. It is very strange that some of them should not occur with these eoliths in the plateau gravels, that in many places they should not overlap and be found mixed together, and *that nowhere*, so far as we know, should these same eoliths be found with the remains of extinct animals by which their real age could be tested. How is it they do not occur in the caverns or in the brickearths and gravels of the valleys, and how is it there is no continuity of shape and contour with their successors? It is these questions which stiffen our obstinacy and increase our scepticism about these so-called eoliths.

A few words about another matter. As we have seen, the real and logical distinction in Europe between the so-called Palæolithic and the so-called Neolithic age is the existence of a gap hitherto unbridged. On the one side we find articles of human workmanship associated with extinct beasts, and on the other with domesticated animals, the two never having been found mixed together. This is the real and supreme distinction; for in regard to the shapes of the implements, their mode of tooling, etc., intermediate forms occur—perhaps I ought to say *necessarily* occur. The significance of this gap is a polemical subject. To me it has always meant a great catastrophe, and I have urged it in many ways and produced the evidence for it in many quarters, and was never more convinced of its occurrence than at this moment. I have never, however, argued that this catastrophe, whatever it was, overwhelmed the greater part of Africa. That continent seems to have a very long history as a continuous subaerial surface. Its black races represent very primitive forms of man, many of them hardly changed for thousands of years, and living apparently very much in the same way and with the same surroundings as Palæolithic man had in Europe.

Palæolithic man may therefore be said to still survive in Africa. It is consequently not wonderful that in several places on that continent, notably in South Africa, in Somaliland, and in the Sahara, implements called Palæolithic have occurred in large numbers, not buried in

gravel beds containing the bones of extinct animals, but lying about on the surface, their age being therefore quite indefinite. To call them palæoliths seems a misnomer, for that term has an archæological sense in Europe and defines a geological horizon which it is impossible to equate with anything in Africa, where traces of the catastrophe we have mentioned and of the gap which it caused are not available. And if we are to justify the use of the term, it must be apart altogether from its defining a geological period or a particular archæological horizon, and merely as marking a stage of culture. Hence we have had recently a mighty fight, which has been largely upon the connotation of a name. This fight has occupied the pens of Sir John Evans and Dr. Forbes, both of whom have written with the skill and knowledge that might have been expected of them. The issue has been complicated by the fact that Africa north of the Atlas Mountains is zoologically and archæologically a part of Europe. In Algiers evidence is ample that the same destruction of Pleistocene animals, marked by their rapid entombment in gravel and brickearth, took place as occurred in Europe; and there, as in Europe, the traces of Palæolithic man, properly so called, have been found in the gravels and drift-beds associated with the extinct beasts, a fact to which Sir John Evans has called especial attention. In the valley of the Nile similar remains of man were found long ago by General Pitt-Rivers in the breccias and coarse gravels of the great valley, and here also may claim to be truly Palæolithic. But in the case of the surface implements from Somaliland and the country of the bushmen, we must, if we are to be precise, be careful that in applying the term Palæolithic we do not in some way imply great age, for all it may mean is a mere survival, just like the survival of the stone lamps of the Esquimaux and the stone pots and pans of the Hebridean cottiers.

II.—The Circulation of Salt and Geological Time.

By Professor J. Joly, M.A., D.Sc., F.R.S.

FROM time to time I have received from correspondents suggestions that the method of determining the geological age of the Earth by the rate of solvent denudation of sodium might be open to considerable error if the allowance made in my paper (Trans. R.D.S., ser. II, vol. vii), for sodium chloride carried from the sea by winds and washed from the atmosphere by rain, was seriously at fault. These suggestions arise from incomplete study of the quantities involved. Had more space been given in my paper to this question, the hasty criticisms I have had to contend with, doubtless, would be less often advanced. The whole matter is capable of the simplest arithmetical statement, and the limit of error arising from this source easily defined. Recently one gentleman has written at considerable length on the matter in the pages of the *Chemical News*. I have replied to Mr. Ackroyd in that journal. But the definition of the limit of error referred to,

and the consideration of some other points raised in the discussion, are more in place in a geological than in a chemical journal. I would therefore seek for space in the GEOLOGICAL MAGAZINE wherein to repeat in part what I have said in the *Chemical News*, adding some matters more especially suited to geological readers.

If all the chlorine in rivers were combined with sodium present in the river-water, much the larger part of the sodium would remain over. The quantity of sodium in river-water which finds its equivalent of chlorine in the water requires special consideration. It obviously may in part be derived from the ocean by the agency of winds and rains. That this part *only* can be considered as derived from such a source a simple proof is given later on. The question then arises as to what amount of sodium chloride is observed to fall in rain, or what amount of chlorine falls with rain; the assumption being made, not quite accurately, that the sodium carried by rain is measured by the chlorine present.

Very full information relating to the chlorine content of rain-water falling in various parts of England and Scotland, and some other coastal parts of the world, is on record. What is wanted is fuller knowledge of the chemical character of rains falling in inland areas, more especially as to their content of sodium. The broad fact at our disposal is, that as we proceed inland a rapid diminution of the percentage of chlorine appears. In inhabited parts of Europe but 200 miles from the sea, the proportion observed appears to be one-twelfth, normally, of what is observed 30 or 40 miles from the sea. In India, about 300 miles from the sea it was found to be 0·04 per 100,000.

In a country like ours where no point is more than a few score miles from the sea, coastal conditions prevail over its entire area. Even within the small British area, however, there appears to be a rapid diminution in the proportion of chlorine carried by the wind to more inland parts. This is observed even in the more inhabited parts, notwithstanding the fact pointed out by Dr. Angus Smith that where coal is being consumed on a considerable scale this proportion must be expected to rise. Although this is so, I do not think it can be doubted that a large part of the chlorine of British rivers, and of well waters also, must be sea-derived. A simple comparison of the chlorine content of British surface waters and of rain, bearing in mind the inevitable concentration of the latter by evaporation, sufficiently demonstrates this fact. This is pointed out in my paper "An Estimate of the Geological Age of the Earth" (p. 35).

In inland countries on the other hand it is extremely doubtful, according to our present knowledge, if *any* of the chlorine observed in rain is derived from the sea, for the circulation of salt from the earth to the air or from inland salt deposits, along with other mineral dust, may be accepted as *inevitable*. Raised with every wind, again washed down with rains, evaporated to dryness, and again raised mingled with the light dust of soils, an amount of saline matter comparable with so minute a quantity of chlorine as was observed

in India might well circulate from the earth to the air, and be returned by the rains to the rivers. Such chlorine is, of course, derived by solvent denudation from the soils.

Mr. Ackroyd (*Chemical News*, June 7th, 1901) goes so far as to assume that the inland salt lakes must owe their salts mainly to wind-borne chlorine. That some of the salt lakes of the earth situated near the ocean, or in the track of storms, or even of prevailing winds from the sea, derive contributions of salts from the ocean, is probable. Calculations have been made by Pierre in France and others showing how considerable in amount the salts carried from the sea in immediate coastal regions may be. It is, however, only necessary to refer to the chemical composition of the salt lakes themselves to see that any such origin for the greater mass of the salts present is totally inadmissible. The Dead Sea, for instance, shows a very large excess of magnesium salts over sodium salts, their chlorides constituting 15·9 per cent. and 3·6 per cent. respectively of the total solids. There is even a large excess of calcium over sodium in its waters. In the Great Salt Lake the proportions are just the other way; the percentages are nearly marine, 11·9 of sodium chloride and very little magnesium chloride, but 1·1 per cent. There is relatively very little calcium. Now this is the more embarrassing for Mr. Ackroyd's hypothesis, in that the first lake is close to the sea, the latter very remote from it. Thus the lake which is most favourably situated for the rain supply of sea-salts is just that one which most completely departs in its chemical composition from that of the ocean. Again, we find a lake such as the Elton Lake of the Kirghis Steppe, 200 miles from the Caspian, possessing a chemical composition approximating to that of the Dead Sea: 19·7 per cent. of Mg Cl, 5·3 per cent. of $MgSO_4$, and 3·8 per cent. Na Cl. Calcium is, however, in its case absent or inappreciable. Now while the observed wide differences in chemical composition are entirely at variance with a pluvial origin, the rain being supposed to derive its burden from the common reservoir of the ocean (almost homogeneous in composition), they are quite in accord with an origin by solvent denudation, as a glance at the considerable differences of river analyses will show, and as indeed would be *a priori* inferred from the wide range of solubility and chemical composition of the surface materials of the earth.

But all indirect arguments as to the magnitude of the error which might arise from the circulation of sea-salt must be used in subordination to a simple demonstration, on the known facts, of the magnitude of the *maximum* error possible from this source. The estimation of the maximum error is easily arrived at.

Professor Dittmar in his report on the chemical composition of the ocean shows that the amount of chlorine present is *in excess* of the sodium, so that attaching chlorine ions to sodium ions there remains over a large excess of chlorine, appearing in the statement of total solids as 10·8 per cent. of Mg Cl. We have, in fact, 77·7 per cent. of Na Cl and 10·8 per cent. of Mg Cl. A simple calculation will show that it results that 18 per cent. of the Cl must be

otherwise allocated than to the sodium, or is, in short, in excess of the Cl equivalent of the sodium present.

Now it is certainly a fair assumption that if rain receives its salts from sea spray a similar excess of Cl ions over Na ions will obtain in rain-water. We must at least conclude (in deference to the current belief that the proportions of salts in rain-water and sea-water are not generally quite in accord) that the sodium equivalent of the chlorine found in rain-water constitutes an excessive estimate of the former. Pierre's results, to which I have already referred, fully confirm this statement. He finds, in kilogrammes received per hectare per annum, quantities of sodium chloride and other chlorides, as well as of sodium sulphate, which afford 29·7 kilos of chlorine and 17·72 kilos of sodium. Ascribing to this amount of sodium its equivalent of chlorine, we have still a balance of over 8 per cent. of the chlorine.[1]

We now turn to what we know of the chemical constitution of river salts. I take Sir J. Murray's mean analyses of nineteen chief rivers of the world. Here we find the striking fact that there is *a large excess of sodium over chlorine*: or the conditions of the sea are reversed. We find, in fact, 157×10^6 tons of sodium and 84×10^6 tons of chlorine carried to the ocean per annum, and as the combining weights of these elements are to one another as 23 : 35 it will appear that considerably the larger part of the sodium of rivers must exist otherwise combined than with chlorine, were the ionizing conditions removed. Let us now go so far as to assume that *all* the chlorine in rivers is derived from rain, and that this brings into the rivers its *full equivalent* of sodium, and we can obviously calculate the maximum possible effect upon the age of the Earth arising from the circulation of salt. (This can fall short of the maximum only on the assumption of a selective retention of chlorine in soils, for which I know of no evidence.) In this method of treating the quantities at our disposal we leave, in short, the whole of the sodium equivalent of the chlorine of rivers out of account in deducing the age of the Earth. The result of the new calculation is that the previous estimate of 96 millions of years rises to under 148 millions of years. This result is, however, over the maximum deducible even from the foregoing assumptions, for as we diminish our estimate of the chlorine derived by solvent denudation during geological time we increase the estimate we necessarily make for original sodium in the ocean derived by a primeval acid denudation effected by free H Cl (for we must

[1] Pierre's figures for the several salts in the units mentioned above are—

Na Cl	37·5
K Cl	8·2
$Mg Cl_2$	2·5
$Ca Cl_2$	1·8
$Na_2 S O_4$	8·4
$K_2 S O_4$	8·0
$Ca S O_4$	6·2
$Mg S O_4$	5·9

A rainfall of 60 cm. per annum is assumed.

assume so much more chlorine to have been free in the original atmosphere), and thus we are bound to diminish our numerator as well as our denominator. The final result would be 141×10^6 years. In obtaining this figure we simply assume that no part of the chlorine now in the ocean was at any time contained in the rocks, and that in a period of primeval acid denudation it acted as H Cl to bring chlorides into the original ocean. In other words, that the $28{,}316 \times 10^{12}$ tons of Cl now in the ocean took part in the primeval denudation, 6·7 per cent. of it uniting with sodium, and thus bringing $1{,}250 \times 10^{12}$ tons of sodium into the primeval ocean, the calculation being made on the basis defined in my paper. Deducting this from the $15{,}627 \times 10^{12}$ tons of Na now in the ocean, we have $14{,}377 \times 10^{12}$ tons to be accounted for by the annual river supply. On our present assumptions the annual supply is not to be taken at its full value of 157×10^6 tons, but this reduced by the sodium equivalent of the whole of the chlorine in rivers (that is, the equivalent of 84×10^6 tons), i.e. 55×10^6 tons. The geological age is therefore the quotient of $14{,}377 \times 10^{12}$ by 102×10^6, which is rather less than 141 million years.

The assumptions made in obtaining this upper limit are, I need scarcely point out, unjustifiable. We are not at liberty to ascribe all the chlorine of the rivers to rain. Whether derived directly from the rocks and soils, extravasated deposits (as when contained in ore deposits), or from accumulations due to past or present inland denudation in 'rainless' areas, this element, so far as it is a carrier of sodium, must enter our denominator. Nor can we assume the chlorine of rain-water a fair measure of sodium transported from the sea, seeing that such chlorine, if directly sea-derived, should, to the extent of 18 per cent., exist combined with magnesium or other element, and according to observation does so exist to the extent of over 8 per cent. And again, what chloride of sodium is found in rain-water is very surely in part derived from the land. Finally, what we know of the percentage of chlorides in inland rains points to a supply inadequate to furnish the quantities appearing in Sir J. Murray's analysis of mean river-water, for of coastal rains by far the greater part finds its way back quickly and directly to the sea by the small rivers and streams, and does not enter into the composition of the larger rivers, the catchment areas of which are either far inland or rise on the land side of the great mountain ranges. The amount of chlorine appearing in the mean river-water is a little over 0·30 part per 100,000. Contrast this with the estimate 0·04 obtained 300 miles from the sea in India, or the Darmstadt estimate 0·09 part per 100,000, both localities being still relatively close to the sea. On all these grounds I have restricted my allowance for rain-borne chloride of sodium to 10 per cent. of what appears in rivers.

We might base an allowance on the scanty knowledge we possess as to the chlorine content of rains falling some 300 miles from the sea. Let us accept 0·10 per 100,000 as the average amount of Cl carried by rains to the rivers after evaporation, and assume that all

this was of marine origin and brought with it its full equivalent of sodium. We thus assume that one-third of the chlorine in rivers is derived from the ocean. We will now calculate what correction on the 96 millions of years this allowance will involve.

The total chlorine discharged by rivers annually into the ocean is 84×10^6 tons, and 33 per cent. of this is 28×10^6 tons; this is, we assume, derived from the ocean. Of the total Cl discharged by rivers we see that 56×10^6 tons (the part derived from the rocks) are not cyclical.

The 33 per cent. of chlorine which is wind-carried, as we assume, has a sodium equivalent of $18{\cdot}4 \times 10^6$ tons. Deducting this from the total annual river supply of sodium, i.e. from $157{\cdot}3 \times 10^6$ tons, we have $138{\cdot}9 \times 10^6$ tons derived from the rocks.

Let now N = the sodium now in the ocean = $15{,}627 \times 10^{12}$.

n = the quantity of sodium derived from solvent denudation and discharged annually by rivers = $138{\cdot}9 \times 10^6$.

C = quantity of chlorine now in the ocean = $28{,}316 \times 10^{12}$.

c = quantity of chlorine derived by solvent denudation and annually discharged by rivers = 56×10^6.

(All in tons.)

If now X = Geological Time, we see first that the quantity of chlorine cX was derived from the rocks during the time X, and therefore the amount $C - cX$ must have originally been free in the primeval atmosphere. I have shown in my paper on the Age of the Earth that there is reason to believe that 6·7 per cent. by weight of such free chlorine would take up sodium from the earth-crust. Consequently, the weight of sodium brought in, expressed as a fraction of the free chlorine, is $\frac{6{\cdot}7}{100} \times \frac{23}{35}$, the last fraction being the ratio of the combining weights. This factor becomes 0·044 when reduced. In other words, the mass of sodium brought into the primeval ocean was $0{\cdot}044\ (C - cX)$.

Hence the equation for Geological Time will be—

$$X = \frac{N - 0{\cdot}044\ (C - cX)}{n}$$

and from this we have—

$$X = \frac{N - 0{\cdot}044\ C}{n - 0{\cdot}044\ c}$$

Inserting the numbers given above, we get $X = 105 \times 10^6$.

Allowing, as I have done in my first paper, a deductive correction for direct coastal denudation, we may state our final result as just about one hundred millions of years. We are not justified in stating our result more definitely. We keep in mind that our knowledge of river analysis and of ocean mass are certainly not final.

So far, then, as error from rain-borne chloride of sodium can affect our result, surely the limits are fixed with sufficient straitness! We have, without any further deductions, 96 millions of years if we accept the correction of 10 per cent. on the chloride of sodium of

rivers; we have 105 millions of years if the correction should be 33 per cent. I do not believe an unbiassed consideration of the knowledge at our disposal will permit of an allowance *larger* than the latter.

I have given the foregoing estimation in its algebraic form in consequence of the remark of a writer in *Nature* (in a review of my paper) that it was a pity that the age of the Earth has to be *assumed* in making allowance for the primeval acid denudation. Such assumption of the duration we seek to determine is not, however, necessary, as the foregoing algebraic statement shows.

The teaching of the calculation which I gave in my original paper, that the missing sodium of the rocks is equal to or in excess of that added to the ocean during geological time, has been taken by some as by no means opposed to the view that the ocean may have primevally contained the greater part of its present sodium, or to a rapid convergence in the rate of solvent denudation.

The greater part of these sediments, we are assured, were laid down under conditions not even inimical to life, or, as Sir Archibald Geikie has contended for the very ancient Torridonian rocks, under physical conditions much as obtain to-day. But this is not all. The oldest sediments are just those which are chemically the least impoverished and the least washed out of the whole series, and, indeed, might almost be identified by their higher alkali percentages. This fact is obviously quite opposed to the view that they were exposed to more intense solvent actions than obtain to-day. In a word, the internal evidence, chemical, physical, and organic, afforded by the successive strata, controverts the convergence of denudative activity which some have casually assumed, and in the light of this fact the calculation in question *does* oppose the theory of a sodium-charged primeval ocean. We are assured, in fact, that the introduction of sodium age by age had to wait upon the denudation of the rocks, and was thus regulated by a rate to which we know of no disturbance.

III.—On the Enon Conglomerate of the Cape of Good Hope, and its Fossil *Estheriæ*.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

In the "Annual Report of the Geological Commission" published at Cape Town in 1895, Dr. Corstorphine refers at pp. 16–19 to the extent and features of the Enon Conglomerate, and to the occurrence of fossil *Estheriæ* in some of its strata. His two assistant geologists, Messrs. A. W. Rogers and E. H. L. Schwartz, in their "Reports on the Southern Districts between Breede River and George" and "On Oudtshoorn," at pp. 73, 76–79, describe in detail the position and characters of the Enon Conglomerate and its '*Estheria* shale.'

This Conglomerate (with its sandstones and shaly beds) occurs in the Breede River valley, Worcester Division of the Western Province,

and extends to Ashton and the Swellendam Division, just south of the Langebergen; it covers also a large area eastwards as far as Mossel Bay, and along the valley of the Olifant's River in the Oudtshoorn District, just south of the Great Zwarteberg range. This formation consists of a quartzose conglomerate with a ferruginous cement, and with intercalated, variable, lenticular sandstones. In general it is less than 50 feet thick, but in some places the conglomerate hills rise 400 feet above the valleys (pp. 16 and 17).

At about 30 miles east of Swellendam, and 20 miles from the sea, there is an outlier of Enon Conglomerate, on which are the two towns of Heidelberg and Riversdale. In the vicinity of the former rises the Duivanhocks River, which runs down to the sea at St. Sebastian Bay. Near Heidelberg occur the shaly arenaceous strata, with multitudes of flattened *Estheriæ* on the bed-planes.

The name 'Enon Conglomerate' was first used by Dr. W. Guybon Atherstone (*Eastern Province Monthly Magazine*, vol. i, No. 10, June, 1857, p. 528), for the quartzose conglomerate which he noticed at Enon, in the Alexandria Division of the Eastern Province, among the upper waters of the Sunday's River, on the flank of the Zuurberg. The name has been adopted by others, and used particularly in Mr. E. J. Dunn's Geological Map of South Africa.

Mr. A. G. Bain's section and remarks at p. 58, vol. vii, Trans. Geol. Soc., ser. II, 1845, indicate this conglomerate and some overlying portions of the Wood-bed series of the Uitenhage Jurassic formation, in Lower Albany, north of the Bushman River. Mr. Bain also noticed (op. cit., p. 184) the occurrence of the Enon Conglomerate, with ferruginous cement, "at Lange Kloof and other parts of the district of George," as well as "on the flank of the Zuurberg" and "at Grobbelar's Kloof near Graham's Town."

In the *Mining Journal* for July 3rd, 1886, the following arrangement was given by me for this conglomerate and associated strata:—

Jurassic: Uitenhage Formation[1]	*Trigonia* Beds	400? feet.
	Wood Bed	
	Saliferous Bed	
	Zwartkop Sandstone ...	
	Enon Conglomerate ...	300 feet.

(Unconformable or Devonian and other old rocks in Albany.)

At pp. 76–78 of the Rep. Geol. Comm. for 1898 it is stated that "The Enon Conglomerate extends from the Paardeberg eastwards, as a huge sheet covering up the Bokkeveld Beds on the south and the Malmesburg Beds on the north. It lies in the middle of the valley between the Zwartebergen and Langebergen. Typically it consists of pebbles of quartz and quartzite, imbedded in a dark red matrix, but varieties occur which are very similar to those in the conglomerate south of the Langebergen. Along the Gamka Flats there are white gravels with large boulders similar to those in Honig Klip's Kloof, and along the Olifant's River on the west there are green sandstones and white claystones [?], the same as

[1] See also Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 149 and 167.

one finds north-west of Heidelberg. The Enon Conglomerate of the Oudtshoorn District closely resembles, in its lithological character and relation to the older rocks, the similar deposits in the country to the south of the Langebergen. Although determinable plant-remains, with the possible exception of lignite, in which the minute structure has been preserved, have not yet been found in the rock, there are indefinite casts of fragments of wood in the sandstone near Oudtshoorn, which are very like the casts in the sandstone of Cape St. Blaize and Heidelberg."

At p. 19 Dr. Corstorphine remarks:—"The character of the Enon Series—thick banks of conglomerate, passing in most localities within a short distance, vertically and horizontally, into coarse, lenticular beds of sandstone, the latter containing stems and other plant-remains, with fresh-water *Estheria*, and in one instance a coleopterous wing-cover—points to a fluviatile origin for the whole. It is, with the exception of the recent sand-dune limestones and other superficial deposits, the youngest formation in the area so far surveyed."

At p. 18 he states:—"Shales and claystone [?] also occur, sometimes gray, sometimes black and almost coaly in appearance. Near Herbertsdale and Heidelberg the shales are common, and at the former locality they contain numerous plant-remains. At Heidelberg a white shale [shaley arenaceous bed] occurs with abundant *Estheria* casts."

In March, 1899, I received from Mr. A. W. Rogers, one of the Geological Surveyors of Cape Colony, three specimens of Enon Conglomerate collected at Heidelberg, Swellendam District. Two of the specimens (300 *a* and 302 *a*) consist of hard, white, laminated, fine-grained sandstone (not argillaceous nor calcareous), showing bed-planes, covered with flattened valves of *Estheria*. The other is an irregular and slickensided fragment of similar siliceous rock (296 *a*). A large part of it is not laminated, and the matrix seems to have been crushed after consolidation; it contains some imperfect and indeterminable casts and fragments of valves, modified by pressure. These relics are distinguishable by their being stained with yellow ochre. The rest of the piece is laminated, and the bed-planes show many valves crowded together, flattened and modified in their outlines. Their surfaces mostly present the appearance as if the outer layer or film of shell had been dissolved or melted, as it were, into a very thin, sometimes brownish varnish or glaze; and no reticulate or other ornament between the concentric ridges can be discovered in these valves.

Looking at the striking general similarity of the numerous variable, sub-oblong, and sub-oval shapes in the crowds of extremely flattened valves on these bed-planes, we evidently see the result of shoals of probably one kind, or local tribe, of *Estheria* having been suddenly enveloped in heavy deposits of mud; and it is difficult to distinguish any specific difference among the individuals.

Venturing, however, to place them all under one quasi-specific title, I group them as Estheria anomala, sp. nov. (Figs. 1–4).

On specimen 302 *a* there is one individual (Fig. 1) which has retained in great part the shape of the bivalved carapace, but is rather narrowed vertically. The left valve remains exposed, and a portion of the dorsal region of the other valve protrudes beyond it.

This left valve has the oblong-ovate shape common in the genus, and bears indications of numerous concentric close-set lines or ridges. It measures 5 mm. in length and 3 mm. in height.

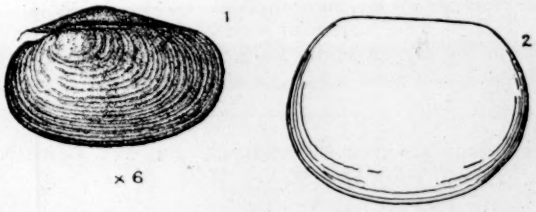


Fig. 1.—*Estheria anomala*, sp. nov. Carapace showing the left valve, somewhat narrowed by crush. Magnified 8 diam.
Fig. 2.—A right valve, crushed quite flat. Magnified 8 diam.

A modified right valve (Fig. 2), on the same specimen, quite smooth, and widened out by pressure until it is almost suborbicular, measures 5·75 mm. in length and 4·5 mm. in height, and yet may be of the same species as the foregoing, there being many intermediate shapes on the bed-planes of this rock.

On specimen 300 *a* are other flattened valves, often nearly suborbicular. Fig. 3, which has a short and broad ovate form, with an apparently short but distinct dorsal border or hinge-line, measures 6·25 by 4·25 mm., and may be taken as belonging to the specific type. The spaces between the concentric ridges (Fig. 4) exhibit no ornament.

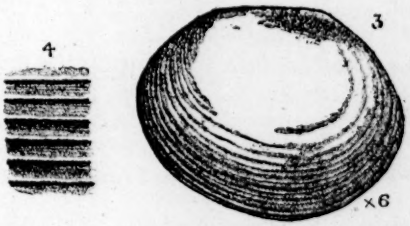


Fig. 3.—*Estheria anomala*, sp. nov. A right valve, somewhat misshapen by pressure. Magnified 8 diam.
Fig. 4.—Part of the surface of Fig. 3. Magnified 75 diam.

None of the *Estheriæ* above mentioned from the Enon Conglomerate of Heidelberg correspond with the three known South African species:—

Estheria Greyii, Jones: Geol. Mag., 1878, p. 100, Pl. III, Fig. 1. This differs altogether in the general shape. It was from the Lower Karoo beds, near Cradock, Cape Colony.

Estheria Draperi, Jones: GEOL. MAG., 1894, p. 289, Pl. IX, Figs. 1 *a*, *b*, *c*. This sub-oblong form is much larger, and has ornamented interspaces, but is the nearest in general form. It was from the Uppermost Karoo beds, in the Drakensberg, Natal.

Estheria Stowiana, Jones: GEOL. MAG., 1894, p. 290, Pl. IX, Figs. 2 *a*, *b*. This little valve differs from the others especially in its sub-elliptical outline. Having its full complement of numerous concentric ridges, it is not a young form, as suggested in 1894. From the Uppermost Karoo beds, in the Drakensberg, Natal.

IV.—On the Reported Occurrence of the Camel and the Nilghai in the Upper Miocene of Samos.

By C. I. Forsyth Major, M.D., F.Z.S.

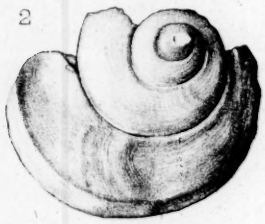
In a notice on "Fossil Camels in Europe," inserted in the periodical *Natur und Haus* (1901, ix, 5, p. 179), it is stated that amongst the fossils from Samos in the Stuttgart Museum there occurs, under a wrong name, the well-preserved skull of a Camel, and likewise "a near relative of the Indian Nylgau, *Portax pictus*."

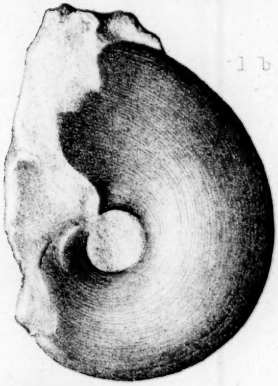
On a visit to the Stuttgart Museum a few weeks ago, I was kindly allowed to examine the above-named specimens, with the result that the skull supposed to be a Camel is found to be that of a hornless member of the Giraffidæ, agreeing almost exactly in form with hornless skulls of *Samotherium Boissieri*, Maj., but considerably smaller. It is doubtless the female skull of *Palæotragus Rouenii*, Gaud.

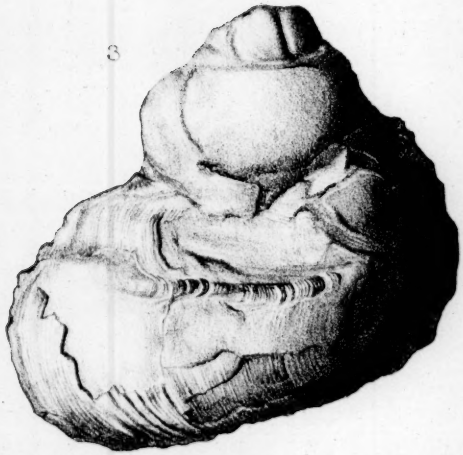
Breadth of frontals behind the orbits in a *Samotherium Boissieri* ♀ ...	240·5 mm.
Breadth of frontals behind the orbits in the Stuttgart skull	187 ,,
Breadth of frontals across the orbits in the Stuttgart skull	161 ,,
Breadth of frontals across the orbits in *Palæotragus Rouenii*, according to Gaudry	160 ,,

The hornless *Camelopardalis parva*, Weith., from Pikermi, is the same species as *Palæotragus Rouenii*. The difference in the shape of the molars is only apparent, the examination of the type-specimen of the latter in the Paris Museum showing that the teeth are not correctly drawn in fig. 2, pl. xlv of the "Animaux fossiles et Géologie de l'Attique."

The fossil claimed to be a near relative of the *Portax* is likewise a Giraffoid, intermediate in size between *Samotherium Boissieri* and *Palæotragus Rouenii*; the incorrectly repaired supraorbital horn of the left side is preserved. In size and shape the molars correspond with (1) some isolated teeth doubtfully assigned by Gaudry to his *Camelopardalis Attica*; (2) an "isolated upper tooth series" from Maragha (Persia), described by Rodler & Weithofer; (3) isolated teeth, also from Maragha, in the British Museum (M. 3,867 and 3,869); (4) the teeth of the type-specimen of *Giraffa vetusta* (Wagn.), from Pikermi, if due account is taken of the latter's rather worn condition. The Stuttgart skull shows the characters of *Palæotragus*







G.M. Woodward, del. et lith. West, Newman imp.

Silurian Gasteropoda

and *Samotherium* (the unfortunate former name will presumably, as previously stated by me, supersede the latter); it is therefore probable that its anterior and posterior limbs were of approximately the same relative length as in *Samotherium Boissieri*, and not giraffe-like as in *Camelopardalis Attica*. If this suggestion proves to be correct, the proper name for this intermediate-sized member of the Giraffidæ will be *Palæotragus vetustus* (Wagn.).

The hornless skull and the teeth described under the name of *Alcicephalus Neumayri* in Rodler & Weithofer's paper on the Ruminants of Maragha (1890) belong to *Samotherium Boissieri* (1888); not so the limb-bones ascribed to *A. Neumayri*, which agree better with the size of *Palæotragus Rouenii*.

It is but fair to state that there are labels in the Stuttgart Museum to show that the Giraffoid affinity of the two fossils in question had been duly recognized.

V.—Woodwardian Museum Notes: Salter's Undescribed Species. V.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XV.)

Pleurotomaria striatissima (Salter). (Pl. XV, Figs. 1 and 2.)

1873. *Pleurotomaria striatissima*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 171 (*a* 987, *a* 991).
1891. *Pleurotomaria striatissima*, Woods: Cat. Type Foss. Woodw. Mus., p. 113.

There are two specimens of this species in the Woodwardian Museum, both of which were named and labelled by Salter. The smaller and more perfect one, *a* 987 (Fletcher Collection), is first mentioned, and is stated to have come from the Lower Ludlow of Dudley. The larger specimen is from the same horizon of Green Quarry, Leintwardine, and shows only a portion of the upper surface.

Diagnosis. — Shell much flattened, discoidal; very low, short spire; whorls five or six in number, much flattened, coiled into a nearly flat spiral; outer whorl with acute margin furnished with small, narrow projecting band, marked off by groove from rest of whorl, and bordered by a raised thread-like line above and below (shown in Leintwardine specimen). On the inner whorls this band lies on the suture-line and is almost hidden. Apical surface of whorls ornamented with regular, equidistant, longitudinal, revolving striæ, 30–40 in number. At about one-third the distance from the outer margin is a raised thread-like line or keel, parallel to the striæ and more conspicuous on the inner whorls. Umbilical surface of shell flattened or very weakly convex, swelling slightly towards the mouth (which is not preserved). This surface is ornamented with revolving striæ, similar to the apical surface, but there is no raised thread-like line or keel amongst them. Umbilicus deep, circular, and about one-fifth the width of the base.

MEASUREMENTS.

	mm.
Diameter of larger specimen	35
Diameter of smaller specimen	22

PLEUROTOMARIA UNIFORMIS, Salter. (Pl. XV, Fig. 3.)

1873. *Pleurotomaria uniformis*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 155 (*a* 879).

Salter (*loc. cit. supra*) described this species as "large, quite without ridges except band." His original specimen (*a* 879), from the Fletcher Collection, is the only one which we possess, and it is poor material on which to base a new species, as it is distorted and the shell mostly missing. It was found in the Wenlock Limestone of Dudley, and measures approximately 65 mm. in length and 60 mm. in width across the body-whorl.

DIAGNOSIS.—Shell large, broadly conical, of few whorls (the three upper ones are alone preserved). Whorls convex, with apical face oblique to axis and having its surface slightly raised in the middle between the suture-line and slit-band. Slit-band of moderate width, marginal, separating apical face from convex portion of whorl below, and situated above the middle line of the whorl; with rounded prominent borders, and with a convex surface crossed by transverse crescentic striæ and occasionally by thicker lamellæ. Suture-line shallow. Body-whorl large, apparently nearly half the length of shell. Ornamentation of apical face of whorls consisting of transverse sigmoidal lines; rest of whorls crossed by transverse non-sigmoidal striæ, with a few thicker striæ interspersed at irregular intervals.

PLEUROTOMARIA ? HELICOIDES, Salter.

1873. *Platyschisma helicoides*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 186 (*b* 140, *c* 26).
1891. *Platyschisma helicoides*, Woods: Cat. Type Foss. Woodw. Mus., p. 111.

The two specimens on which Salter founded this species are both from the Upper Ludlow of Lesmahagow. Neither is at all well preserved, and but very few characters are visible. Salter says of this species: "A shell very like the *Trochus helicites* of the British Ludlows, but flatter and having a marked subangular band."

DIAGNOSIS.—Shell small, coiled into a low spiral of five or six whorls. Whorls angulated; apical surface narrow, flat, horizontal, with elevated keel round edge; sides steeply sloping. Margin of last whorl appears to be expanded into horizontal lamellar band. No slit-band visible. Surface ornamentation unknown.

MEASUREMENTS.

	mm.
Height	2·5
Width	7·0

REMARKS.—As Salter remarks, this species is quite distinct from Sowerby's *Trochus* [*Platyschisma*] *helicites*,[1] but it is unfortunate

[1] Sil. Syst., pp. 603, 706, t. iii, figs. 1*e*, 5. Siluria, 4th ed., p. 162, Foss. 26, fig. 9; t. xxxiv, fig. 12.

that the material is so badly preserved that even the genus is doubtful. It is quite possible that it is a *Horiostoma*, but the apparently alate margin reminds one of *Pleurotomaria alata* (His.),[1] and the shape of the whorls is also similar, especially in the variety *subcarinata*.

TROCHONEMA BIJUGOSA, Salter. (Pl. XV, Fig. 4.)

1873. *Trochonema bijugosa*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 875).
1891. *Trochonema bijugosa*, Woods: Cat. Type Foss. Woodw. Mus., p. 115.

There are only two specimens of this species in the Woodwardian Museum, and they are the original ones determined by Salter. The larger one shows a portion of the body-whorl and succeeding whorl with the shell well preserved; the smaller one is merely an imperfect internal cast of the two basal whorls, and it is doubtful if it is rightly attributed to the same species. Both are from the Wenlock Limestone of Dudley and belong to the Fletcher Collection. Salter describes the species as "much resembling *T.* (*Turbo*) *trochleatus* of McCoy and Hall," and the figure in the margin appears to be a rough restoration of it.

DIAGNOSIS. — Shell conical, turbinate; of six (?) whorls; apical angle 60°. Whorls angulated by two parallel longitudinal keels, between which their surface is flattened and vertical. Apical surface of whorls sloping down steeply from suture-line to upper keel, but swollen into a low, revolving ridge close below suture-line, defined below by distinct groove. Lateral surface flattened vertical, about one-third height of whorl, bounded above by upper keel and below by lower keel; lateral surface meets apical surface at angle of 45°, and in basal whorl meets umbilical surface at same angle. Umbilical surface sloping, faintly convex. Keels forming rounded, projecting, parallel bands, marked off above and below by faint narrow grooves. The lower keel is rather the larger of the two. Surface of valves ornamented by regular, continuous, strong, equal striæ. On apical surface the striæ are oblique, and close to the upper keel bend sharply back and cross it in a series of sharp crescents resembling those on the slit-band of *Pleurotomaria*. Between the keels on the lateral surface the striæ are nearly straight and vertical, and cross the lower keel directly without bending back, and continue thence on to the umbilical surface, where they become sigmoidal.

MEASUREMENTS.

	mm.
Width of larger specimen	20·0
Estimated height of ditto	20·0

REMARKS. — It is unfortunate that the material on which this species is based is not more complete, and accordingly the species does not admit of very satisfactory definition. At any rate, it seems to be distinct from any previously described.

[1] Lindström: Sil. Gastrop. Pterop. Gotl., p. 118, pl. x, figs. 33–37.

BELLEROPHON RUTHVENI, Salter. (Pl. XV, Figs. 5 and 6.)

1873. *Bellerophon Ruthveni*, n.sp., Salter: Cat. Camb. Sil. Foss. Woodw. Mus. (*b* 61).

1891. *Bellerophon Ruthveni*, Woods: Cat. Type Foss. Woodw. Mus., p. 96.

It is to be regretted that the four specimens on which Salter founded this species are so poorly preserved and distorted. They are all from the Kirkby Moor Flags of Benson Knot, near Kendal, and were labelled by McCoy *B. expansus* (Sow.). Salter describes *B. Ruthveni* as "Smaller than *B. dilatatus* and with the band angular, and the whorls angular where the band becomes so. Very common, 1¼ inch wide." The shape of the shell resembles *B. expansus* with large expanded aperture, with inner lip bent down considerably and outer lip possessing a wide acuminate V-shaped sinus. The slit-band is comparatively narrow, and lies sunk between faintly elevated margins. Near the aperture the whorl seems to be slightly carinated and compressed, though this appearance may be due to crushing in the rock. In one of the smaller specimens there are traces of one or two longitudinal thread-like lines running parallel to the slit-band on the surface of the shell, slightly diverging towards the mouth, but no other ornamentation or surface-markings are visible. The specimens are so poor that it is impossible to give any satisfactory definition of the species, and it is extremely doubtful in my mind whether Salter's species can stand.

EXPLANATION OF PLATE XV.

FIG. 1*a*.—*Pleurotomaria striatissima*, Salter, viewed from above, enlarged twice natural size.

FIG. 1*b*.—The same, viewed from beneath, enlarged twice natural size.

FIG. 1*c*.—Side-view of same, enlarged twice natural size.
From the Lower Ludlow of Dudley.

FIG. 2.—*Pleurotomaria striatissima*, Salter, natural size; from the Lower Ludlow, Leintwardine.

FIG. 3.—*Pleurotomaria reniformis*, Salter, natural size; Wenlock Limestone, Dudley.

FIG. 4.—*Trochonema bijugosa*, Salter, enlarged twice natural size; Wenlock Limestone, Dudley.

FIG. 5.—*Bellerophon Ruthveni*, Salter (side-view), natural size; Kirkby Moor Flags, Benson Knot, Kendal.

FIG. 6.—The same (carinal aspect), enlarged twice natural size; same locality.

VI.—ON THE BRITISH EARTHQUAKES OF 1900.

By CHARLES DAVISON, D.Sc., M.A., F.G.S.

(WITH A MAP.)

DURING the past year there were only two undoubted earthquakes in this country. Some may have occurred in Glen Garry, one of our most sensitive regions; but the construction of a new railway through the valley renders it difficult to identify true earthquakes with certainty. The total number of British earthquakes during the last twelve years thus amounts to 116, of which 46 had epicentres in England and Wales and 70 in Scotland, 42 of the latter number being confined, or almost confined, to Glen Garry.

Ochil Earthquakes of Sept. 17 and 22, 1900.

The two undoubted earthquakes occurred on Sept. 17 at 10.15 p.m. and Sept. 22 at 4.30 p.m. There were also four other reported shocks, whose seismic character is not established, at the following times:—

(*a*) Sept. 17, 3.30 p.m., Menstrie.
(*b*) Sept. 17, 10.5 p.m., Alva.
(*c*) Sept. 18, 2 a.m., Alva.
(*d*) Sept. 18, about 2.55 a.m., Bridge of Allan.

The first two were noticed by several persons at each of the places mentioned, but I have no record of them except the statement that slight shocks were felt.

Earthquake of Sept. 17, at 10.15 p.m.—I have received 56 accounts of this earthquake from 26 places, in addition to negative records from 11 other places.[1] The epicentre is situated among the Ochil Hills, and consequently the intensity of the shock in the central region is unknown. At places near the boundary, in the valleys of the Forth and Allan, the intensity was 4, and it can hardly have exceeded this degree in any part of the disturbed area.

The boundary of the disturbed area, which corresponds to an isoseismal line of intensity slightly less than 4, is roughly elliptical in form, 15 miles long and 9½ miles broad, and includes 117 square miles. Its longer axis is directed E. 13° N. and W. 13° S., and the centre of the area is 3 miles N. 32° W. of Alva. In spite of the absence of observations from the neighbourhood of Glendevon, it is probable that the curve is drawn with a fair approach to accuracy.

The shock seems to have been nearly uniform in its character all over the disturbed area, a single prominent vibration succeeded by a tremor such as would be caused by a heavy weight falling on the floor and making the building shake, and lasting altogether not more than three seconds.

Of the 55 observers who provide detailed accounts of the earthquake, 48 distinctly heard the sound, 4 are doubtful or fail to answer the question, while 3 state that they heard no sound at all. Thus, the percentage of those who heard the sound is not less than 87. A few observers describe the sound as a loud sharp crash or a low rumbling sound, while as many as 41 refer it to one of the ordinary types. Of these, 29 per cent. compared it to the noise of heavy waggons or traction-engines passing, 10 per cent. to thunder, 5 per cent. to wind, 12 per cent. to the tipping of a load of coal or bricks, 17 per cent. to the fall of a heavy body or the banging of a door, 12 per cent. to blasting or explosions, and 15 per cent. to miscellaneous sounds, such as the trampling of horses, a distant waterfall, a large flock of pheasants flying over the house, or the rush of heavy rain against the window. On the whole the frequency of comparison to sounds of short duration is unusual, and this no doubt is due mainly to the prominence of the heavy thud that

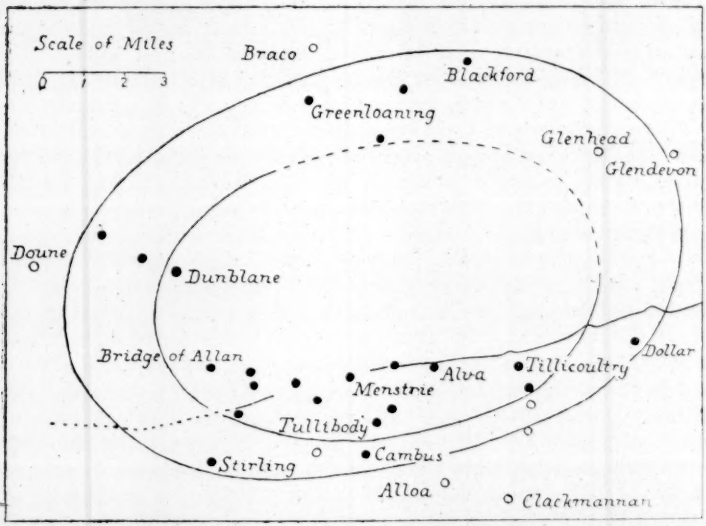
[1] The outer curve on the map and all places marked refer to this earthquake.

accompanied the principal shaking, while the rumble which died away with the tremor was unnoticed or undescribed.

The beginning of the sound preceded that of the shock in 10 cases and coincided with it in 19; while the end of the sound preceded that of the shock in 2 cases, coincided with it in 17, and followed it in 3 cases. The time-relations of both initial and final epochs are given by 22 observers, and these show that the sound was of greater duration than the shock in 8 cases, and of equal duration in 12, while in 2 others the relative duration is doubtful.

Earthquake of Sept. 22, *at* 4.30 *p.m.*—This shock was weaker and less widely observed than the preceding, and I have not more than 20 accounts from 13 places, together with negative records from 15 places. The intensity of the shock was 4, and probably was not much greater even near the epicentre.

The boundary of the disturbed area is an isoseismal of the same intensity as that of the earlier shock, that is, slightly less than 4. In the north-east quarter, the boundary is indicated by a broken line, being doubtful owing to the absence of observations in this part of the disturbed area. It is 11 miles long and 7 miles wide, and contains an area of 60 square miles. The longer axis is parallel to that of the other shock, and its centre is $2\frac{1}{2}$ miles N. 37° W. of Alva.



Though slighter, the shock closely resembled that of the 17th inst., one observer (at Bridge of Allan) describing it as a sudden abrupt loud shock, as if some extremely heavy body had fallen outside the house, followed immediately by a tremor.

The earthquake-sound was recorded by 13 out of 15 observers who enter into details, that is, the audibility-percentage, as in the first earthquake, was 87. Of the few observers who describe the

sound, 9 per cent. compare it to passing waggons, 27 per cent. to thunder, 9 per cent to wind, 36 per cent. to a cart of coals or bricks being emptied, 9 per cent. to the fall of a heavy body, and 9 per cent. to the distant firing of cannon. Thus, the reference to sounds of brief duration is even more marked than in the earlier shock. The beginning of the sound preceded that of the shock in 2 cases and coincided with it in 5; while the end of the sound coincided with that of the shock in 4 cases.

Origin of the Earthquakes.—From the seismic evidence, we can determine only the direction of the originating fault, which must be about E. 13° N. and W. 13° S. If it hades to the north, the fault-line must lie to the south of the centres of the disturbed areas, and if to the south on the north side.

On the map of the earthquakes is shown that part of the great Ochil fault which traverses the disturbed areas of the earthquakes. Its general direction is E. 11° N. and W. 11° S., and, if the fault haded to the north, it would thus satisfy the seismic conditions; but this, I am informed through the kindness of Sir A. Geikie, is not the case. "It is known to hade to the south both by direct observation and by the effects of denudation upon the intrusive sill of dolerite in the Carboniferous rocks, where it is thrown against the andesites and agglomerates of Lower Old Red age." As the shock would be less strongly felt on the hard compact rocks of the Ochil Hills than on the softer rocks to the south, it follows that the earthquakes cannot be attributed to slips along the Ochil fault.

There is no other parallel fault of any consequence marked on the Survey map (Sheet 39), though several faults cross the Ochil Hills in a nearly perpendicular direction. The only conclusion we can come to, therefore, is that the earthquakes are connected with some fault or faults, whose existence has not yet been ascertained by geological evidence.

Doubtful Earthquake.

Pendleton (near Manchester), April 7, 1900.—An earth-shake, somewhat similar to that of Feb. 27, 1899, occurred at 1.17 a.m. on April 7. Mr. Mark Stirrup has again kindly sent me records of this shock, from which it appears that the disturbed area, as before, is not more than 4 or 5 miles in diameter, and that the centre is close to the Irwell Valley fault, but a mile or two further to the south or south-south-east of that shaken in 1899. At Pendleton the vibration resembled that felt in a house when a heavy traction-engine passes; and the sound appeared as though the mortar and walls were being crushed. In the collieries, at a depth of about 3,000 feet, the noise was also considerable; and the shock is said to have caused dust to rise. As the intensity of the shock was 4 or 5, and the disturbed area very small, the depth of the centre of disturbance must have been slight. The evidence is less complete than in the former case, but, so far as it goes, it supports the view of the origin of these earth-shakes in mining districts which I suggested in my last paper on British earthquakes.

Spurious Earthquakes.

Shortly after 10 p.m. on July 18, a series of disturbances was observed at different places along the south coast of England, between Torquay and Brighton. At first they were supposed to be earthquakes, but they were afterwards traced to the gun-firing during a sham fight which took place at Cherbourg at the hour mentioned in honour of the French President's visit to that town. The evidence for this conclusion is as follows:—(1) The area within which the sounds were heard was a narrow band hardly more than a mile or two wide, following all the windings of the coast, and interrupted in that part of Hampshire shielded from Cherbourg by the higher ground of the Isle of Wight. (2) The disturbances occurred in groups, each of which lasted several minutes. (3) The waves were obviously propagated through the air, for they caused a drumming in the ears, and windows were shaken while floors were still. (4) Lastly, the sounds were recognized as those of heavy guns, and were ascribed to this origin with a confidence which increased with the observer's neighbourhood to Cherbourg.

VII.—Geological Notes from Tanganyika Northwards.

By Malcolm Fergusson, Esq.

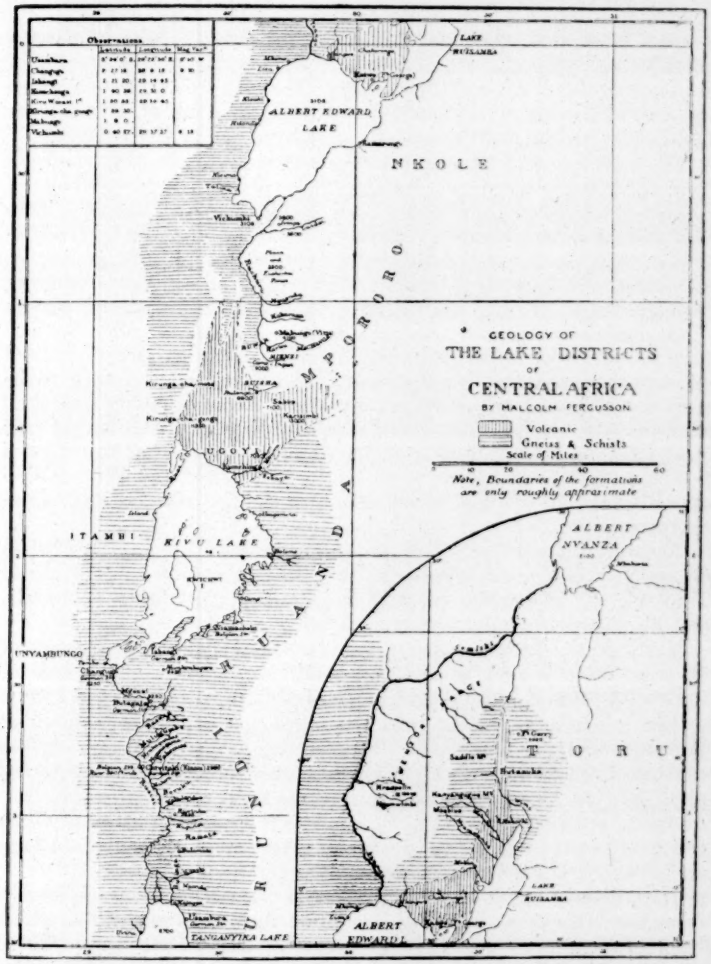
(WITH TWO MAPS.)

THE southern shore of Lake Tanganyika and the country for a distance of 40 miles south of the lake consist of sandstones and conglomerates, dipping north about 10°. These sandstones stretch some little way up the eastern and western shores, and appear to continue away to the south-west. Proceeding further north along the lake shore they get harder, being in places metamorphosed into a pink quartzite.

In colour the sandstones are reddish or grey, generally very coarse. At the lake they are of enormous thickness, being quite 3,000 feet at Kituta, and they surround the southern shore in a precipitous horse-shoe which descends to the water's edge. On the west coast they come to a sudden stop at the Lufu Valley, where there is a break in the range, the plateau descending to the level of the lake into which the Lufu River flows. Here the geology changes, and an intrusive dyke of quartz-felsite comes in, followed by a lava-flow which has every appearance of stratification, and which I mistook for a sedimentary deposit at a distance. It is a rhyolite which has poured down the Sumbu Valley into Cameron Bay, the present appearance being a bank of rhyolite rising from the beach.

["Under the microscope the rock has a brecciated appearance, owing to the intermingling of lenticular pink (or in one specimen dark) spherulitic patches with colourless, finer-grained, microfelsitic material showing well-marked flow-structure. A few small phenocrysts of quartz and altered felspar (mainly oligoclase) are present."]

Immediately north of this rhyolite the country begins to rise again, splitting up into small detached hills at first and gradually rising to mountains of quartz-felsite at Moliro's. ["This rock contains fairly large phenocrysts of quartz and orthoclase in a microfelsitic base showing flow structure and in parts also spherulitic structure."]



Crossing now to the eastern shore, we find the sandstones continue up as far as the German station of Kasanga, but just north of this they terminate and felsitic rocks again intrude and predominate, granite sometimes showing up through the mass. As we

proceed further north the felsite disappears, and at Mpimbwi occur granite, gneiss, and schists. ["A specimen of gneiss or crushed granite from this locality presents under the microscope a good example of cataclastic structure with long irregular patches of quartz (showing marked undulose extinction), some microperthite, and bands of sericite in a mosaic of crushed quartz and felspar."]

While at Kilando we experienced three earthquake shocks, only a small interval of time elapsing between them. The missionaries say they are of frequent occurrence, especially during the months of September, October, and November. Here the plateau is broken up, and the country descends in altitude to hills of 400 feet or 500 feet in height, with sometimes extensive plains and valleys.

The occurrence of felsitic rocks on both sides of the lake suggests that the rift had occurred through the middle of a large mass of this rock which originally had been continuous, and that the lake was formed subsequently.

Recrossing to the western shore at Tembwi we find granite, gneiss and schists with a large quantity of white quartz veins running through them. Going north and approaching the Lukuga Valley these gradually descend, breaking up into low ridges and hills, and give place to deep red sandstones, which, however, are only of limited extent and appear to be quite recent, as I found what I took to be crab markings on the surfaces, and they were probably deposited along a river valley. The river was evidently of much larger size at one time, and even now is of considerable size during the time of floods, as evidenced by the great width of the bed and the position of native dwellings, which are all situated high up and back from the banks.

The only known deposit of limestone in the Tanganyika district occurs at the French mission station Mpala, a few miles south of Tembwi. It is a white crystalline limestone, containing no fossils, and supplies the whole district with lime.

North of the Lukuga the country is almost flat for a distance of 10 miles or so and for some way inland. About one mile north of the outlet there is a small stream, the Lubui, flowing *into* the lake.

Ten miles from the Lukuga the country rises sharply again at Kahangwa, where I landed to look at the formation which strikes out into the lake in a sharp bluff composed of dark-grey contorted phyllite. At Mtowa the formation seems to be principally schists.

Again crossing the lake, I found soft grey sandstones which continue north to Ujiji, but in many places here is open plain land and the rock is covered with soil and vegetation.

Immediately north of Ujiji the country rises again precipitously from the lake shore, showing sandstone formation containing thick beds of conglomerate, dipping generally east about 20°. These sandstone beds rest on granite, which can be seen above the water line at Viuwko and Lumungi.

North of Lumungi the sandstones give place to granites, gneiss, and schists, which form the main constituents of the mountain range running north along the shore and up past Usambura, where

they bend east a little and form a large open fertile plain, enclosed by these mountains on the one side and by the Western Congo Range on the other.

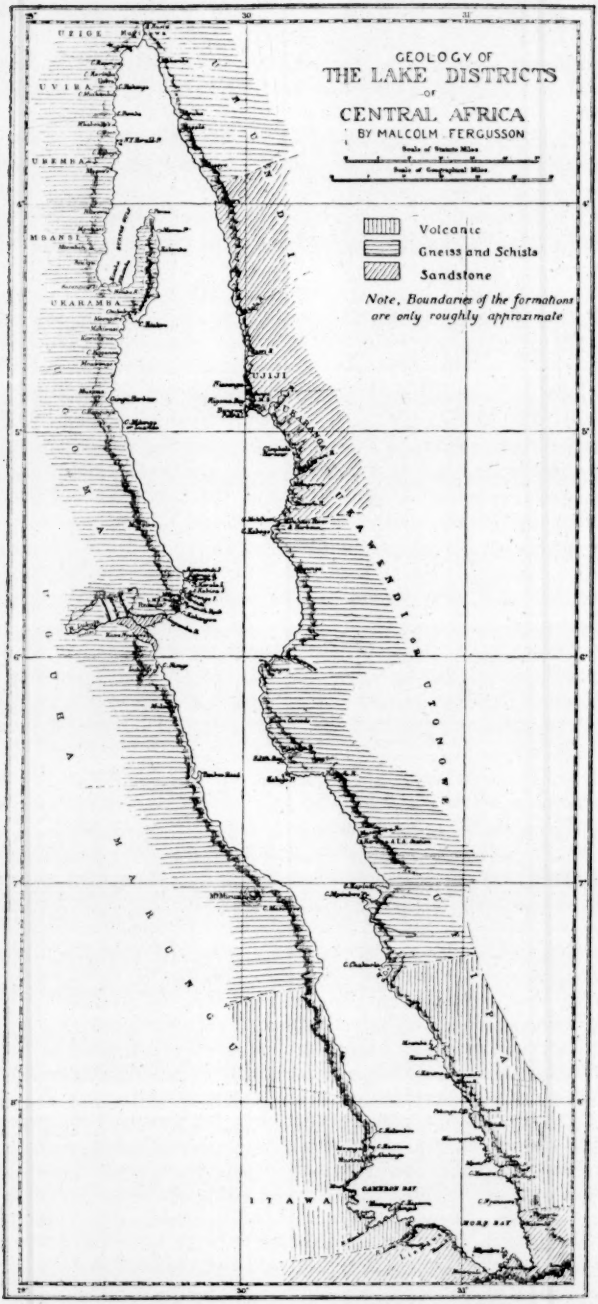
Referring to the question of Tanganyika having been once connected with the sea, it is impossible to state definitely any ideas on the subject from the limited observations I was able to make, but the enormous thickness and extent of the sandstones on the southern shore, extending southwards forty miles and then bending round and continuing west, give one the idea that this might have been an old arm of the sea connecting Tanganyika westward by way of the Congo. If the sandstones could be traced towards the Congo the problem might be solved. Connection northwards at any time seems to me impossible. The mountain range at Kivu forms a dividing barrier, in fact is a north and south watershed, from which the waters flow south to Tanganyika and north to the Nile.

North of Tanganyika is a broad fertile alluvial plain covered with grass, euphorbias, and scrub, extending north for about 25 miles. Then spurs come down from the main ranges east and west, and from here the country is hilly.

Just south of Butagata, the German station on the Rusisi, occur some hot springs. From here the country rises again sharply for about 2,300 feet, with rounded hills covered with deep red soil showing no outcrop of rock. This continues round the south-eastern shore of Lake Kivu. Then gneiss and schists come in which continue northwards as far as the volcanic area. In one place, on the north-eastern shore at which we landed, I found a white fissile rock. ["This rock is very similar to rocks from Abyssinia, which have been referred to sölvsbergite (see Min. Mag., 1900, xii, p. 265), the fissile character being due to the platy arrangement of the felspars. Under the microscope it shows a trachytic felt of small felspar laths with interstitial, minute, ragged patches of a pale-green augite. From its poorness in coloured minerals the rock is best referred to the bostonites."]

The main eastern range comes down to the lake and extends along the east and north shores as far as Kumchengi, then continuing north; the western range also follows the lake shore and strikes north, forming a valley similar to the Rusisi Valley north of Tanganyika; but this valley of Kivu is filled with lava which has been poured out from several volcanoes, of which two are still active, emitting steam and sulphurous fumes. The larger of these, Kirunga-cha-gongo, is 11,350 feet in height, and the crater is about one and a half miles in diameter at the top. It has been recently eruptive, as can be seen by the streams of lava cutting through the forest.

The lava seems to be extremely scoriaceous everywhere, and has poured down southwards into the lake and northwards almost as far as the Albert Edward. The line of volcanic action seems to be proceeding from east to west, as there are six or seven large extinct cones almost in a line east of this, and the two active ones are at the western extremity.



Map of Lake Tanganyika.

Around the large cone, Kirunga-cha-gongo, there are many smaller cones which appear to radiate off along definite lines of weakness. Thus :—

The great Western or Congo Range here consists of granite, gneiss and schists, the schists increasing in proportion as it gets further north, till at the Albert Edward the whole range appears to be composed of mica-schist.

Lake Kivu, whose only outlet is the Rusisi, does not seem to have fallen in level at any time, as there are no signs of old terraces round the shores, and there are many old trees growing close down to the shore, cemented in by a sort of concrete wall formed by spray dashing up on the boulders and pebbles, evaporating and leaving a deposit of carbonate of magnesium. The floor of the lake is in places paved with this deposit.

Generally the lake is deep right up to the shore. It has every appearance of having been formerly simply a river running down the valley northwards into the Albert Edward. The volcanic eruptions then took place in the valley, filling it up with lava and damming up the water, which gradually rose and flooded the banks till it found an outlet south by way of the Rusisi into Tanganyika. The natives call it 'The River.'

A curious point about the water of Kivu is that, unlike ordinary water, which contains a solution of calcium carbonate, it contains a solution of magnesium carbonate. The floor of the lake is paved with what appears to be a precipitate of this substance, and the pebbles and boulders around the shore are cemented with it. There are no dolomites or other magnesium rocks, as far as I could see in the district; therefore the inference is that springs containing magnesium carbonate in solution must be feeding the lake and keeping up a constant supply.

["The quantity of water received and the state of preservation were not such that reliance could be placed on quantitative results, but from analyses made by Mr. J. Hart Smith, A.R.C.S., it is evident that magnesium replaces calcium in the water, the analytical and spectroscopic evidence showing that traces only of calcium salts are present. Fragments obtained from the lake floor, consisting of a calcareous tufa evidently deposited round vegetable *débris*, were analyzed by Mr. W. Robertson, A.R.C.S., and were found to contain Ca O 28·65, Mg O 12·66 per cent. as the mean of two closely agreeing analyses."—W. E. W.]

Lake Albert Edward is a shallow lake throughout, with a sandy

bottom. The natives can pole their canoes nearly everywhere, only occasionally having to resort to paddles. The lake is not in a 'rift' like Tanganyika, but has more the appearance of an overflow.

Immediately north of Albert Edward, at Katwe Fort George, a white volcanic tuff occurs. ["It is on the occurrence of these tuffs round 'crater-lakes' that the idea of considerable recent volcanic activity at the foot of Ruwenzori mainly depends.[1] The present tuff shows signs of stratification, with parallel flakes of biotite and muscovite, so that it has been probably rearranged by water. Microscopic examination shows that it consists by no means wholly of volcanic material. It contains small angular fragments of a biotite-granite or gneiss, oligoclase, quartz, biotite, brown hornblende, pink garnet, and colourless augite. Any doubts, however, which might have been entertained as to the volcanic origin of these 'tuffs' were set at rest by an examination of the tuff collected by Mr. Scott-Elliot, and referred to as No. 96 in the paper already cited. Under the microscope this tuff is seen to be made up mainly of round lapilli, of which the larger ones consist of a mere shell of glassy volcanic material surrounding fragments either of biotite or of a granitic or gneissic rock, which must have been torn from the walls of the vent during the eruption."] Tuffs with crater lakes, hot springs, and cones continue up to Ruwenzori and around the eastern foothills to beyond Fort Gerry. There are salt lakes around Katwe. The foothills of Ruwenzori are composed of gneiss; beyond and above this mica-schists occur, dipping steeply; and still higher, nearer the centre of the mountain, epidiorite[2] is the predominating rock.

The accompanying Figure shows a section of the mountain as approached from the east.

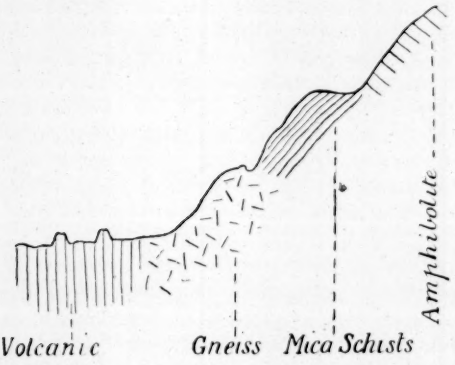


Diagram-Section on the East side of Ruwenzori.

Proceeding eastwards from Toro, the prevailing rock is gneiss as far as Uganda, with occasional dolerite dykes. ["A specimen of these dolerites consists of large ophitic plates of a nearly colourless augite, felspar laths, and large plates of ilmenite; in parts in the interstices

[1] Scott-Elliot & Gregory: Quart. Journ. Geol. Soc., 1895, li, p. 674.
[2] Scott-Elliot & Gregory, l.c.

of the felspars were ophitic plates of quartz. In its quartz contents and general character the rock is strikingly similar to quartz-dolerites (diabases) of the Transvaal (e.g. rock from near Potchefstroom)."] To the west of Lake Victoria sandstones overlie the gneiss and continue round the lake shore for some distance. This gneiss formation is again in evidence on the eastern shore, and continues up the Nandi plateau till the volcanic disturbances from the eastern rift valley occur at Mau.

["The rocks collected in this volcanic region consist mainly of phonolites and phonolitic trachytes. Most of them contain phenocrysts of anorthoclase and ægirine-augite in a trachytic groundmass of felspar-laths, through which are distributed irregular grains and feathery patches of augite, and of soda-hornblendes closely related to, if not identical with, *Cossyrite* and the *Catophorite* of Brögger. Some of them contain olivine in small amount, and in this respect as well as in their more glassy character approach closely to the pantellerite-like rocks or *Kenytes* of Mt. Kenya described by Gregory.[1] An anorthoclase phonolite from Mau differs from the phonolites on the east side of the rift valley in containing large crystals of a remarkably pleochroic (colourless to deep rose-red) sphene, which appears to have crystallized about the same time as the augite phenocrysts, since in some cases it includes augite and in others is included by that mineral. Besides the phonolites there is also a specimen of andesitic hornblende-enstatite-basalt, somewhat similar in character to the so-called enstatite-porphyrite from Schneidemüllerskopf, Thuringia."]

North of Lake Naivasha I found a deposit of very pure diatomaceous earth containing fragments of obsidian, and on account of this I imagined it to be a volcanic tuff till Mr. J. J. H. Teall examined it and found it to be full of diatoms. ["The obsidian chips appear to be worked implements similar to those from the same neighbourhood described and figured by Gregory ('The Great Rift Valley,' p. 324)."]

The diatomaceous earth has been examined by Mr. Thomas Comber, who finds that it consists of fresh-water species, of which he has identified the following:—

1. *Neidium affine*, Cl., forma major, V. H.
2. *Anomœoneis sphærophora*, Cl.
3. *Diploneis ovalis*, Cl.
4. *Pinnularia acrosphæria*, Rbh.
5. *P. legumen*, Ehr.
6. *Navicula bacilliformis*, V. H.
7. *N. pseudobacillum*, Grun.
8. *N. pupula*, Kutz.
9. *N. Tuscula*, Grun.
10. *N. slesvicensis*, Grun.
11. *N. radiosa*, Kutz.
12. —— var. *tenella*, Breb.
13. *N. mutica*, Kutz.
14. *Cymbella lanceolata*, V. H.
15. *C. cistula*, V. H., var. *maculata*, Kutz.
16. *C. cymbiformis*, V. H.
17. *C. parva*, Cl.
18. *C. leptoceras*, Kutz.
19. *C. turgida*, Greg.
20. *C. amphicephala*, Naeg.
21. *Gomphonema gracile*, Ehr.
22. —— var. *aurita*, Breb.
23. *G. intricatum*, Kutz.
24. *G. subclavatum*, Grun.
25. *G. montanum*, Schum.
26. *Amphora ovalis*, Kutz.

[1] Quart. Journ. Geol. Soc., 1900, lvi, p. 205.

27. *Cocconeis placentula*, Ehr.
28. —— var. *lineata*, Grun.
29. *Achuanthidium lanceolatum*, Breb., var. *dubia*, V. H.
30. *Epithemia gibba*, Kutz.
31. *Epithemia gibba*, var. *parallela*, V. H.
32. —— var. *clavata* (= *E. clavata*, J. L. B., MS. in Coll. R. M. S.).
33. —— var. *ventricosa*, Kutz.
34. *E. zebra*, Kutz.
35. —— var. *proboscidea*, Kutz.
36. *E. sorex*, Kutz.
37. *E. gibberula*, Kutz.
38. *Ennotia incisa*, Greg.
39. *Fragilaria mutabilis*, Grun.
40. —— var. *intermedia*, Grun.
41. *F. construens*, Grun.
42. —— var. *venter*, Grun.
43. *F. virescens*, Ralfs.
44. *Synedra splendens*, Kutz.
45. *S. ulna*, Ehr.
46. *S. oxyrhynchus*, Smith.
47. —— var. *nova*, var. *mesolepta*.
48. *Odontidium mesodon*, Kutz.
49. *Surirella linearis*, Smith.
50. *S. Smithii*, Ralfs (a large form of it).
51. *Nitzschia tenuis*, Smith.
52. *N. amphibia*, Grun.
53. *Stephanodiscus astræa*, Grun.
54. —— var. *spinulosa*, Grun.
55. *Cyclotella Kutzingiana*, Thwaites.
56. *C. operculata*, Kutz.
57. *Melosira granulata*, Ralfs. } These three run into each other.
58. *M. crenulata*, Kutz. } These three run into each other.
59. *M. tenuis*, Kutz. } These three run into each other.
60. *M. distans*, Kutz.

My deepest thanks are due to Mr. G. T. Prior, of the British Museum (Natural History), to Dr. Wynne, of the Royal College of Science, and to Mr. Thomas Comber,—to Mr. Prior for his kindness in examining and naming the rock specimens, and in supplying the petrographical descriptions; to Dr. Wynne for chemical analyses of water and rocks, and for the deep interest he has shown in the matter; and to Mr. Comber for his exhaustive examination of the diatomaceous earth.

NOTICES OF MEMOIRS.

I.—The Geological History of the Rivers of East Yorkshire, being the Sedgwick Prize Essay for the year 1900. By F. R. Cowper Reed. 8vo. London (Clay), 1901, 4*s.* nett.—The selection of the dependence of the watercourses of a country upon its geological structure as the subject of the Sedgwick Essay for 1900, gave Mr. Reed an opportunity of turning out a piece of work on a subject which has not received that attention in this country it has deserved. The district chosen by the author for his investigations has been carefully surveyed and mapped, and due acknowledgment has been made of the work of the Officers of the Geological Survey, and particularly of that of Mr. Fox-Strangways.

Mr. Reed divides his essay into five parts :—(1) General characters of East Yorkshire; (2) Geological structure; (3) Physical history; (4) The present rivers and their relations to the geological structure; (5) The history of the relations of the rivers to the geological structure. His observations are illustrated by maps.

Mr. Reed draws the following conclusions :—"By the preceding examination of the geological and physical evidence we have traced the general outlines of the evolution of the present drainage-system of East Yorkshire through several successive stages, and we find that its history is intimately bound up with that of the whole of Eastern England since Palæozoic times. There are local details

still waiting to be filled in and branches of the subject still to be investigated, but it is believed that they will produce no evidence which will contradict the main results here worked out. The division of the physical history of the region since Cretaceous times into six stages or cycles is based on geological evidence which is practically incontrovertible; the assumptions as to the original slope of the surface and the deformation of the peneplain are supported by orographical measurements and geotectonic considerations of great weight, as well as by being in harmony with evidence from other parts of England; and, finally, the theory of consequent and subsequent streams has been established on a firm foundation by Davis and many other workers in the same field. The hypothesis of the secondary origin of the Moorland anticlinal as a watershed more or less parallel to the original consequent streams has been found to afford a natural and satisfactory explanation of the behaviour and characters of the watercourses which it concerns; and the modifications effected by the Glacial Period have been interpreted in most cases from direct field-evidence."

II.—Rocky Mountain Region of Canada.—One of the last labours of the lamented geologist, George Mercer Dawson, was his presidential address, delivered before the Geological Society of America on December 29th, 1900. It appeared in the Bulletin for February. Dr. Dawson took as his text "The Geological Record of the Rocky Mountain Region of Canada." The address was an enumeration of the several formations now known to be represented, a brief description of each, and a review of the main outlines of the geological evolution of the area in so far as it has been made apparent. Dr. Dawson began by giving a sketch of the physiographical features, then he took the various formations in review, and finally gave an excellent account of the physical history of the area.

III.—Age of the Earth.—Professor Joly's paper on the Age of the Earth, discussed by Osmond Fisher in the Geological Magazine for March, 1900, recalled to the memory of M. P. Rudzki a method of estimation which he had published in Petermann's Mittheilungen in 1895. Rudzki has now published his further researches and results in Bull. Ac. Sci. Cracovie (February, 1901). The paper is printed in French.

IV.—A Fossil Crab and other Trails.—*Cancer proavitus*, a new crab from the Miocene greensand of Martha's Vineyard, is described by Packard in Proc. Amer. Ac. Sci., 1900. It resembles the living *irroratus*, and provides material for some general remarks on the phylogeny of the genus *Cancer*. In another paper in the same Proceedings Mr. Packard describes supposed Merostomatous and other Palæozoic arthropod trails, with some notes on those of *Limulus*. He shows that there is a marked difference between the trails of limuloids and isopods, and that while the trail of *Merostomichnites Beecheri* is limuloid, that of *Merostomichnites Narragansettensis* is isopodal.

V.—Shorter Geological Notes.—In his report of progress of the Lausanne Museum for 1900, Professor Renevier calls attention to a fine collection of fossils received by the Museum from M. Rittener, of Sainte-Croix. The collection contains 2,000 specimens, all of which are properly located and zoned.

A skin and two skulls of the new and remarkable mammal, lately discovered by Sir Harry Johnston in the forest on the borders of the Congo Free State, were exhibited before the Zoological Society at their meeting on the 18th June. Sir Harry Johnston's original idea that the animal belonged to the giraffes was endorsed, it having relations with the extinct Helladotheres. It was named *Okapia Johnstoni*.

Gustav Keller has drawn and Dr. Andreae has described six large wall-diagrams of extinct animals. They are—*Rhytina gigas*, *Elephas primigenius*, *Triceratops* and *Agathaumas*, *Megaceros giganteus*, an Ichthyosaur, and a Plesiosaur. They are published by Th. G. Fischer, of Cassel, and can be bought separately at six marks apiece.

In Symons' Meteorological Magazine for June, 1901, are several matters of geological interest. There is a report of the Second Conference for the International Investigation of the Sea and the Air; there is the programme drawn up by the Leeds Committee for proposed Observations on Dew-ponds; and there is a note on the Norwegian Rainfall Service, in which service snow and rain are measured in separate gauges.

The School of Mines and Industries of Bendigo, Victoria, issues an Annual Report for the year ending June, 1900, of 96 pages. The Macgillivray Museum attached to the School pays special attention to mining matters, and the curator asks for donations of books and specimens connected with the subject. The syllabus of examinations is a full one. The Mining Science Society seems to have had a successful year of work.

REVIEWS.

I.—The Caucasus.

Aus den Hochregionen des Kaukasus. Wanderungen, Erlebnisse, Beobachtungen von Gottfried Merzbacher. 2 vols.: pp. xxxviii, 958 and 964, with 246 illustrations and a map. (Leipzig: Duncker & Humblot.)

Herr Merzbacher has observed the Horatian rule of keeping a book in the desk for nine years, because the journey of which this is the fruit was undertaken in the Summer and Autumn of 1891. He was accompanied by the well-known Alpine climber, Herr L. Purtscheller, who, however, returned rather before his friend, and by two guides from Kals. Though the weather at times was unpropitious they succeeded in ascending several important peaks, such as Elbruz, Tetnuld, Dongus-orun-Jusengi-Baschi, a mountain as difficult as its name, its companion Sulukol-Baschi, Dschanga-tau, Kasbek, Gimarai-Choch, and others,

besides an unsuccessful attempt on Uschba, the Matterhorn of the Caucasus—sixteen peaks in all, ranging in height from 13,000 to over 18,000 feet—together with other excursions during a journey along the greater part of the chain from west to east. After giving some account of his expeditions in the publications of the German-Austrian Alpine Club for 1892, Herr Merzbacher has worked up the material into two bulky volumes. His book must be the outcome of great and assiduous labour, for he has apparently made himself master of the literature of the Caucasus, or at any rate of all that is accessible. He describes the physical characters, geology, glaciers and glaciation, the meteorology, and the ethnology of this great mountain chain, which, unlike the Alps, is more of a bridge than a barrier between the east and the west. He might apply to the Caucasus the well-known epigram "what there is to know I know it," and he places this at the disposal of his reader. The present work differs mainly from the two handsome volumes published by Mr. Douglas Freshfield in 1896 in that it is written more definitely from the scientific point of view, and thus is practically a monograph on the Caucasus. Both works contain good maps and are enriched with numerous illustrations, but those in the one before us, though in many cases excellent, hardly succeed in reaching the level of the best in Mr. Freshfield's book.

To do justice to Herr Merzbacher's work would require an essay, so that it must suffice to notice a few points of special interest to geologists. In the main the author accepts the conclusions in regard to the structure, orography, and geology of the Caucasian chain which I expressed in an appendix contributed to Mr. Freshfield's book. As a mountain system the Caucasus is more elevated, but less complex in structure than the Alps. The author has drawn up a list of the principal peaks in each, which demonstrates that those in the Caucasus tower above their bases (like Mont Blanc above Chamonix) fully a thousand feet, and sometimes considerably more, than those in the Alps; the crest of the chain also is more elevated, and conspicuous gaps, at any rate in the western half, are fewer. The average height of the snow-line in the Caucasus is 7,690 feet on the north side, and 7,950 feet on the south, though on the former a glacier comes down to 5,791 feet and on the latter to 5,325 feet, but on taking an average of nearly twenty in each case, those on the north side, as might be expected, descend lower by about 240 feet. On two points Herr Merzbacher inclines to differ from me. The mention of some important conglomerates in beds of Miocene age led me to infer that the Caucasus, like the Alps, had been produced by two sets of earth-movements, the mountain chain being due mainly to the former, the eruptions to the latter. He refers the whole to a single set of movements corresponding with the later or Pliocene age. Again, I thought it more probable that the mountain-making thrusts had come from the north; he gives them an opposite direction. Much may be said on both sides, but so far as I can see, instead of bringing forward any new evidence he contents himself with calling my

opinion "rein theoretisch," forgetting to remark that I carefully stated this to be an hypothesis which, with one or two more, was advanced as being, in my opinion, "the most probable interpretation of such facts as have been ascertained."

Herr Merzbacher collected a fair number of geological specimens, which are minutely described by Dr. L. von Ammon in an appendix. The latter separates them into four groups: (I) the Archæan rocks of the Central *Massif*; (II) diabases and contact rocks from Gimarai-Choch to Kasbek; (III) black shales or slates,[1] and sandstones; (IV) younger eruptive rocks. He also has given a note on some sinter from the hot springs of Saniwa. (I) Additions have been made to the detailed knowledge of the Central *Massif* even since the publication of Mr. Freshfield's volumes, and now Dr. von Ammon describes specimens collected from some of its important summits. Among them is a gneiss, with two species of mica, from Dongus-orun; the rocks on the upper part of this mountain are mostly granitic, and Dr. von Ammon thinks the gneissic character of this specimen may be due to pressure. Next come a white granite, containing, however, some scales of biotite (passing into a chloritic mineral) from Uschba: a biotite granite from Sulu-kol-Baschi; granite with two micas from Tetnuld: green-speckled white granite from Dschanga-tau (these three being the highest rocks on the peaks) with a chlorite epidote schist and a quartzose epidote rock from the last-named mountain, a rather fine-grained green-speckled granite from the peak of Sugan-Tau, and a diabasic rock from that of Tepli. The localities rather than their petrographical character give an interest to all these. So it was with the few which I examined for the late Mr. Donkin in 1887. (II) Gimarai-Choch, 15,676 feet high, lies rather more than five miles to the west of Kasbek. The rock of the actual peak is a diabase, which has been minutely examined, but seems not to be specially interesting, except that a little quartz is present; varieties of the same rock were brought from a rather lower level, on one of which were some glass splashes, doubtless due to lightning; a schalstein or diabase tuff was obtained rather more than 300 feet below the peak, and specimens of sedimentary rocks (*hornschiefer* and *schieferiger hornfels*), probably members of the next group, were also obtained on this mountain. (III) Dr. von Ammon separates these (sedimentary rocks) into three groups: (*a*) the first, dark *schiefer*, he assigns, for reasons presently to be given, to the Jurassic system; (*b*) the second, also black *schiefer*, from the Pirikitelisch range in the Eastern Caucasus and from Daghestan; (*c*) those from Laila. They have been carefully studied, for doubt has been expressed as to their geological age. Favre claimed to have identified *Bythotrephis* in some, and assigned these to the Palæozoic era. This identification, however, has been disputed, so that further evidence is desirable. Most of Herr

[1] The ambiguous word *schiefer* is used. Perhaps some day Continental geologists will put an end to a long-standing confusion by using one term for a cleaved, another for an uncleaved rock. Here, I expect, the rocks are commonly slates.

Merzbacher's specimens are unfossiliferous, while some of the dark *schiefer* contain numerous rutile needles; this, however, is not conclusive, and on the whole Dr. von Ammon is disposed to refer them to the Jurassic period, to which one sandstone, from its fragments of echinoderms, almost certainly belongs. But Herr Merzbacher speaks in his narrative of *schiefer* which he regarded as more ancient, so it is very possible (as I pointed out in 1896) that these dark rocks may be, some of Mesozoic, some of an earlier date. (*c*) The rocks of Laila come next, with which we may consider (*a*) already mentioned. Laila (13,400 feet) is a peak to the S.S.E. of Elbruz, but on the opposite side of the watershed. On it Signor Sella in 1889 found some fragments of crinoids. These, as was explained in the appendix to Mr. Freshfield's book, were considered by Mr. Bather and Dr. Gregory to resemble most nearly *Balanocrinus*, a subgenus of *Pentacrinus*, of late Cretaceous or Tertiary age, while Herr Merzbacher, both then and now, placed them very near *Extracrinus subangularis*, a Liassic species. Dr. von Ammon, after examining some other specimens collected by his friend, agrees with him in the identification and in referring the rocks to the Lias. Fossils were also obtained at a spot in the heart of Daghestan between Tindi and Aknada. Among them are joints of a pentacrinus, which Dr. von Ammon figures, assigning it to a new species, *P. Merzbacheri*, which is near to *P. pentagonalis* (Goldf.), and very probably belongs, like it, to the Callovien, or, at any rate, the Middle Jura. A pecten was also found, which closely resembles *P. personatus* (Goldf.), also a Jurassic form. Hence the upper part of Laila is more probably composed of Jurassic than of Cretaceo-Eocene rocks. (IV) With the younger eruptive rocks comes a specimen from the western summit of Elbruz, obtained possibly at a slightly greater elevation than that which I examined.[1] Dr. von Ammon seems to think my description too brief, but I believe that I omitted nothing of importance, and doubt the utility of enlarging on trivial details. His specimen, however, contains a little hypersthene[2] and quartz, both of which are absent from mine. The rock of which he gives an analysis contains 63·80 of SiO_2, with a rather high percentage of alkalies, viz. $Na_2O = 5{\cdot}47$ and $K_2O = 3{\cdot}26$, but is not otherwise remarkable; very probably the two specimens represent slightly different ejections. He expresses a doubt whether this peak is a broken crater, but the descriptions of earlier visitors (a violent gale gave Herr Merzbacher little opportunity of making observations) seem favourable to the idea. In any case he regards the volcano as comparatively modern, thinking it may have continued its eruptions even into the Glacial Epoch. The remaining specimens, three in number, come from Kum-tube, a mountain rising from the Tschegem-thal on the northern side of the watershed, some thirty miles east of Elbruz. The volcanic rocks, which have been already

[1] Proc. Roy. Soc., 1887, vol. xlii, p. 318.

[2] I have again examined my slice, but though a pyroxene is certainly (I said possibly before) present in grains of rather variable size, most at any rate give an oblique extinction. But I think it may also contain about two flakelets of biotite.

noticed by Abich, break through and alter Jurassic sediments. Some of them are hypersthene-augite andesites (the former mineral dominating markedly in two specimens)—that on the summit distinguished by the epithet *vitrophyrischer*—and another is a hornblende-biotite-dacite. These accordingly seem to be nearly related to the volcanic rocks of Elbruz and Kasbek, and to belong to the same group as those of Ararat.

We have dwelt chiefly on the petrology, because that has received such close attention, but valuable geological information is introduced into the narrative throughout the book. Herr Merzbacher, however, does not forget to notice the physical geography, the natural history, the inhabitants of the various districts, their dress, accoutrements, architecture, and habits of life. All these are abundantly illustrated by reproductions of photographs, which are valuable to the ethnologist, and will be more so in the future, as the distinctive characteristics of tribes once isolated by the obstacles of a mountain region disappear before the advance of European civilization. The book, in fact, is a monument of laborious research and a perfect mine of information, which will be useful alike to the mountaineer, the traveller, and the scientific student.

T. G. Bonney.

II.—Silurian Crinoids of Chicago.

The Paleontology of the Niagaran Limestone in the Chicago Area. The Crinoidea. By Stuart Weller. Bull. Nat. Hist. Survey Chicago, IV, part 1, 153 pp., xv pls., and text-figures; 27 June, 1900.

THE Crinoids of the Niagara Limestone of the Chicago region, including south-eastern Wisconsin, have been the subject of publications by Winchell & Marcy, James Hall, and S. A. Miller. Nevertheless the amount written was by no means proportional to the size of the fauna, and a large number of species escaped notice even in Wachsmuth & Springer's great Monograph of the North American Camerata. This has not been due to want of material, for the collections of these fossils are many and rich, but to their unattractive appearance as, for the most part, internal casts of the theca alone in a coarse dolomite. Gratitude and praise are therefore due to the energetic instructor in palæontology at the University of Chicago, Dr. Stuart Weller, for the trouble that he has taken in deciphering this unpromising material and for presenting the results in this clearly written and clearly illustrated memoir.

The results are of wider interest than might have been anticipated. It was hardly to be expected that Dr. Weller should discover new facts of morphology, nor has he done so. But the Crinoidea, perhaps to a larger extent than the other elements of the fauna, shed much light on the problems of distribution. They are represented by no less than 69 species (Dr. Weller says 68), classified as follows:—Monocyclica, Inadunata, *Stephanocrinus* 1 sp., *Myelodactylus* 1 sp., *Zophocrinus* 1 sp.; Adunata, *Platycrinus?* [probably one of the

Coccocrininæ] 1 n.sp., *Marsipocrinus* 1 n.sp.; Camerata, *Melocrinus* or *Mariacrinus* (the evidence of the fixed brachials suggests the former genus to Dr. Weller, but to me the latter) 1 sp., *Macrostylocrinus* 4 spp. of which two are new, *Corymbocrinus* (i.e. *Clonocrinus*) 2 n.spp., *Eucalyptocrinus* 13 spp. of which three are new, *Callicrinus* 9 spp. of which four are new, the allied *Chicagocrinus* n.g. with 2 n.spp., *Periechocrinus* 7 spp. of which one is new; Dicyclica, Inadunata, *Ampheristocrinus* 1 n.sp., *Cyathocrinus* 3 spp. of which one is new, *Crotalocrinus* 1 n.sp., *Botryocrinus* 1 sp.; Flexibilia, *Pycnosaccus* 1 n.sp., *Lecanocrinus* 2 spp., *Ichthyocrinus* 1 sp., and the doubtful *Gazacrinus* 2 n.spp.; Camerata, *Thysanocrinus* (i.e. *Dimerocrinus*) 4 spp., *Cyphocrinus* 1 n.sp., *Lampterocrinus* 4 spp. of which three are new, *Siphonocrinus* 3 spp., *Archæocrinus* 1 n.sp., *Lyriocrinus* 1 sp. Thus this region "contains, next to the Island of Gotland . . . a larger number of species of crinoids of this horizon than any similar region in the world, so far as is known at the present time." Dr. Weller credits Gotland with 172 species; but, as he rightly says, "these are not all associated in the same stratum." There are probably more than 69 species in bed *f* of Gotland, but fewer in bed *d*, which latter alone corresponds to the Niagaran. Failure to recognize this vitiates the contrast of "only six species of inadunate crinoids in the Chicago fauna against 40 in Gotland," for bed *d* has yielded only two Inadunate species, whereas I, with the classification given above, find nine in the Chicago fauna. In this connection it is interesting to note that bed *d* in Gotland is characterized by abundant Eucalyptocrinidæ, Dimerocrinidæ, and Periechocrinidæ, and that these are the families most largely represented in the Chicago area. The really interesting point, however, is that the crinoid fauna of this area, and indeed the Silurian fauna of the Mississippi valley generally, is related to the contemporaneous fauna of north-western Europe more closely than to the neighbouring New York fauna. The present memoir describes species of *Crotalocrinus*, *Pycnosaccus*, and *Corymbocrinus* (i.e. *Clonocrinus*), genera hitherto known only from England and Scandinavia, if we except a few *Crotalocrinus* stems from Arctic America. Dr. Weller, from the consideration of this and other evidence, concludes that the connection was by way of a "North Polar sea with a great tongue stretching southward through Hudson Bay to about latitude 33°. . . . At the latitude of New York there was a bay reaching to the eastward, in which the Silurian sediments of the New York system were deposited." Labrador, Greenland, and Scandinavia formed a more or less continuous land mass, around which another tongue of the northern sea extended south into Europe. In this connection Dr. Weller raises an imaginary difficulty by saying that "in western Russia the Silurian strata are not exposed"; they are indeed not so fully developed as the Cambrian and Ordovician, but they do occur, and are also found on the mainland of Sweden and Norway and in Belgium, countries in which Dr. Weller's map does not indicate them. These corrections of course do but strengthen Dr. Weller's

suggestion ; but it remains no more than a suggestion, to be confirmed or rejected when our knowledge of Silurian faunas is far greater than it now is. A remembrance of the numerous local variations in the character of the Silurian faunas, and of the sporadic distribution of many genera, especially among crinoids, should make us exceedingly cautious. It is well, however, to keep these broad questions before our minds, since they emphasize the need for the most detailed systematic description and the most exact collecting.

In view of the importance of correctness and exhaustiveness in work of this nature, it may be as well to remedy a few slips and omissions that have very naturally crept in, as well as to make a few minor suggestions. Dr. Weller gives a Bibliography of Silurian Crinoidea, believed to be nearly complete so far as American literature is concerned. It does not, however, contain the names of F. de Castelnau, E. J. Chapman, T. A. Conrad, B. F. Shumard, R. P. Whitfield, or L. P. Yandell; nor is there reference to J. Hall's paper in *Trans. Albany Institute*, x, p. 57, or to Beachler's notes in the *American Geologist*, vii, p. 178, and ix, p. 408. Reference to J. W. Salter's appendix to Sutherland's "Journal," 1852, might give Dr. Weller more information about Arctic American crinoids, while he might be interested in a note of my own on *Brachiocrinus* (*Amer. Geol.*, xvi, p. 213). Neither that genus nor its unique species is mentioned in his very useful list of Silurian Crinoids, which also lacks my *Botryocrinus decadactylus* and *B. ramosus*. A stranger omission is that of *Hapalocrinus retiarius* (Phillips, as *Actinocrinus*). *Hapalocrinus*, which is due to Jaekel, is, as one anticipated, confused with *Haplocrinus*, Steininger. Dr. Weller does not, of course, intend his list as authoritative on nomenclature ; but it is as well to point out that *Cyathocrinus capillaris*, Phillips, is a *Gissocrinus*, that *Poteriocrinus dudleyensis*, Austin, is at all events not a *Cyathocrinus*, that *Pisocrinus milligani*, Mill. & Gurl., is synonymous with *P. quinquelobus*, Bather, and that *Pycnosaccus ornatus*, Weller, is apparently a *lapsus calami* for *P. americanus*, Weller. I may further take this opportunity of stating that *Arachnocrinus*, *Callicrinus*, *Calpiocrinus*, *Cordylocrinus*, *Desmidocrinus*, *Hapalocrinus*, *Lyriocrinus*, *Mariacrinus*, *Patelliocrinus*, *Pycnosaccus*, *Stephanocrinus*, and perhaps other genera, are represented in the Wenlock Limestone or Wenlock Shale of England, although not so indicated in Dr. Weller's list of genera (in some cases through inadvertence). This substantiates the criticism that Dr. Weller's comparative census is, through no fault of his, a little too "previous."

The memoir contains a general account of crinoid structure which should be useful to those for whom it is intended. But is it quite safe to say that the food-supply of a crinoid is increased by its stationary position? The assertion seems to ignore the locomotive power of those crinoids that are not attached as well as the action of ciliary currents. At any rate it is misleading to describe *Carabocrinus* as "a very simple crinoid whose dorsal cup consists entirely of three circles of plates." The definition of the terms 'proximal' and 'distal' applies only to the dorsal elements; for

ventral elements the centre of reference is the oral pole. Figure 13 is labelled *Pisocrinus flagellifer*, a name that is a synonym of *P. pilula*. Fig. 14 is labelled *Cyathocrinus ramosus*, just as all text-book writers persist in labelling it, although in 1893 I proved that the specimen belonged to *C. longimanus*.

The descriptions of the species are clear, but comparison would have been facilitated had the author been at the pains to construct diagnoses; while the labours of his successors might have been lightened had he fixed on type-specimens for his new species and told us in what collections such specimens were preserved. A few minor points also need elucidation. Thus, the description of the arms in *Cyathocrinus cora* does not seem to me to agree with Figs. 8 and 9; since this is the most striking feature of the species, enlarged drawings should have been given. The diagram of *Ampheristocrinus* on p. 67 seems to agree with the new species *A. dubius* rather than with *A. typus*; but this is misleading. The arms of the new species *Lampterocrinus dubius* are said to differ from those of typical species "in having no brachial plates of higher order than the costals," or primibrachs; but since the arms are not preserved, it is hard to see how this can be proved. *Archæocrinus* has hitherto been recognized only in the Trenton Limestone, but a species *A. depressus* is here described, although the elevated median series of anals is not characteristic of the genus. The new species described as *Platycrinus* (?) *dubius* shows no sign of the large interradials usual in that Carboniferous genus, and is more likely to be a *Coccocrinus* or *Cordylocrinus*. Dr. Weller says that for most of his generic descriptions he is largely indebted to the publications of others. It is therefore not clear how much weight is to be attached to his accounts of *Gazacrinus*, *Stephanocrinus*, and *Zophocrinus*, all genera about which fresh information was badly wanted. Dr. Weller's own palæontological work has been quite enough to justify him in publishing his own opinions and descriptions, and such a course would more advance science and would fix the responsibility for certain doubtful statements.

Dr. Weller's further studies in the palæontology of the Niagaran Limestone of Chicago will be awaited with interest. They are likely to fulfil the promise of this first one, and perhaps if the author will take a friendly hint or two they will meet with an even more favourable reception.

F. A. Bather.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 5th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communications were read :—

1. "On the Passage of a Seam of Coal into a Seam of Dolomite." By Aubrey Strahan, Esq., M.A., F.G.S.

The author was informed by Mr. N. R. Griffith in 1900 that the Seven-Feet Seam of the Wirral Colliery had been found to pass into

stone of an unusual character. For a distance of 1,600 yards from the shaft this seam was good, and about 4 feet thick. A little farther in, bands of stone from 1 to 10 inches thick made their appearance in it, and, gradually increasing in thickness, these bands eventually constituted the whole seam, the last traces of workable coal disappearing at 250 yards from the point where the change first began. The boundary of the barren area has been found for a distance of 1,480 yards, and it runs north and south. The stone is at first black, but after weathering it becomes grey, and displays curious structures, among which are pisolitic or mammillated structures, the intervening spaces being filled with coaly matter. One specimen displays woody tissue filled with dolomite. Analyses by Dr. W. Pollard yield from 18·5 to 13 per cent. of magnesia. The phenomena are not those of a 'wash-out,' as there is no sign of erosion, but there is proof that the dolomite was formed in almost motionless water, and the conditions appear to have been those under which a tufa would form. It appears to have been formed on a spot to which clastic material scarcely gained access, and which was reached even by vegetable matter in scant quantity and in a finely divided condition.

2. "On some Landslips in Boulder-clay near Scarborough." By Horace W. Monckton, Esq., F.L.S., V.P.G.S.

In 1893 Mr. Clement Reid drew attention to a foliated structure developed in Drift at Beeston, near Cromer (Proc. Geol. Assoc., vol. xiii, p. 66), and soon afterwards the present author noticed examples of a very similar character in Boulder-clay on the Yorkshire coast. The Clay forms much of the cliffs, and slips, large and small, are very frequent. When the Clay is dry, vertical cracks forming a sort of columnar structure occur, and the Clay breaks away in lumps, while a moister condition causes flow, producing more or less horizontal flow-structure which, as in the Cromer case, has the appearance of irregular bedding. The author illustrated his remarks by photographs of the cliffs taken by himself.

II.—June 19th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communications were read:—

1. "On the Use of a Geological Datum." By Beeby Thompson, Esq., F.G.S., F.C.S.

A proper interpretation of geological phenomena frequently requires that allowance shall be made for differential earth-movements that have taken place since the period under consideration. Present differences of level in rocks of the same age may be due to actual differences in depth of the sea-floor on which they were deposited; but they may also be the result of subsequent differential earth-movements. The rock selected as a datum should combine as far as possible the following characteristics:—It should be thin, of considerable horizontal extension, having similarity in physical characters and palæontological contents over a large area, and

situated as near as possible, in vertical sequence, to the reference deposit. In Northamptonshire three formations meet these requirements—the Rhætic beds, the Marlstone Rock-bed, and the Cornbrash. The author applies the Marlstone rock-bed as a datum to the study of the five chief deep explorations in Northamptonshire, with the following results :—While the old land-surface (below the Trias) now varies in height by more than 250 feet, the variation in thickness of the rocks between it and the Middle Lias only reaches $56\frac{1}{2}$ feet; and although the old land-surface is actually lowest where the Rhætic rocks have not been detected, when compared with the position of the Marlstone it is found to be the highest. The further application of the same method enables the author to recognize Rhætic rocks at Northampton, to correct the record of the Kingsthorpe shaft, and to explain the presence of Triassic saline water in the Marlstone. A revised section of the Kingsthorpe shaft is given. Another point proved is that a general levelling-up process was going on just before the beginning of the Lower Liassic Period, and another at the close of the Middle Liassic Period.

2. "On Intrusive, Tuff-like, Igneous Rocks and Breccias in Ireland." By James R. Kilroe, Esq., and Alexander McHenry, Esq., M.R.I.A. (Communicated by R. S. Herries, Esq., M.A., Sec. G.S., with the permission of the Director of H.M. Geological Survey.)

Many fragmental igneous rocks, although resembling tuffs, cannot be regarded as ejectamenta on account of their character and mode of occurrence in the field. Rocks of this type occur to the east of Lough Eake in Donegal, in the district of Forkhill in Armagh, at Blackball Head in Cork, in Waterford, near Arklow, in Wexford, and elsewhere. Sometimes they consist of partly fused and broken-up felspathic mica-schist merging into felsite-dykes, at other times of brecciated slate, granite, and felsite embedded in a scanty andesitic matrix. At Blackball Head the rocks cross the bedding of the associated sedimentary rocks of the region. The authors agree with Professor Lapworth in considering it possible that "igneous matter making its way between the moving masses may consolidate as sills when the pressure is great. . . . As movement progressed intermittently, we should have the formation of subterranean agglomerates, tuffs, and breccias, which would be forced sometimes between bedding-planes, sometimes into dyke-like fissures." A series of sections is exhibited to illustrate how tuff-like masses invade black slate of Llandeilo age in the south-east of Ireland, generally adhering to the direction of bedding, but frequently cutting across it and detaching numerous pieces from the slate, which are more abundant near the margins of the intrusion than elsewhere. The masses frequently assume a tuff-like appearance. At Arklow Rock tongues of tuff-like rock penetrating black slate of Llandeilo age contain pieces of limestone of Bala age, as well as pieces of the slate. The development of vesicular texture in lapilli-like, contained, fragments may be due to the simple release of pressure.

CORRESPONDENCE.

SUARDALAN, GLENELG.

SIR,—At a recent meeting of the Geological Society, after the reading of Mr. G. Barrow's communication on the supposed Silurian Rocks of Forfarshire, Sir A. Geikie alluded to similar rocks which have been found elsewhere along the Highland Border, and (as reported) he gives to me the credit of having found these rocks in the district lying between Loch Lomond and Callander.

The credit of this discovery does not belong to me, but to my friend and former colleague, Mr. J. R. Dakyns. I merely completed the mapping of the rocks alluded to after Mr. Dakyns left Scotland.

GLENELG, *June* 19, 1901. C. T. CLOUGH.

OBITUARY.

RICHARD HOWSE, M.A.

BORN 1821. DIED 1901.

ALL visitors to Newcastle-upon-Tyne on the occasion of the last meeting of the British Association there, in 1889, remember the large and, in some respects, unique collections displayed in the fine and spacious new building known as the "Hancock Museum." Older visitors will also remember the same collections housed, or rather hidden away, in the cramped and crowded old Natural History Museum at the other end of the city. All must have carried away a pleasing recollection of the handsome, dignified and, latterly, venerable naturalist who was the loving and somewhat jealous guardian of the scientific treasures in both places. Mr. Richard Howse had for so many years been identified with these collections, had for so long watched over, exhibited, and described their rarities, that he had come to be regarded, as it were, as the one living being amongst the multitudinous dead things around him, and it is difficult to think of them bereft of his animating presence. Mr. Howse was no ordinary Curator. Born in Oxfordshire in 1821, much of his boyhood was spent in collecting the land and fresh-water shells, the birds and eggs, and especially the fossils which abound round Thame, his native place. At a very early age he came and established himself as a schoolmaster at South Shields, and from that time—for some sixty years—his residence in the North of England was unbroken. From the moment of his arrival on Tyneside he made the study of the natural objects of the land and sea about him the main purpose of his life. To his extraordinary activity as an observer and collector all the scientific publications of the North bear witness. His name is to be found repeatedly quoted in—I think I may say—*every* one of the many lists of plants, animals, or fossils which make the Transactions of the Newcastle and Berwickshire Societies so valuable as sources of accurate reference. He was fortunate in coming at a time when

Dr. Johnston of Berwick, Albany Hancock, and Joshua Alder were working out the Invertebrates of the North-East coast, when the materials for Baker's "Flora" were being accumulated by Watson, Bowman, Wailes, and Oliver, when George Tate of Alnwick was classifying the Lower Carboniferous rocks of North Northumberland, and William Hutton, with Lindley and Witham, was bringing out his Fossil Flora, when King was beginning his Permian work, when Bold was cataloguing the insects of the district, and when John Hancock and Hewitson were studying its birds and their eggs. Mr. Howse was a fellow-worker with all these men and, later, with Atthey, Norman, Hodge, Embleton, Kirkby, Duff, Dinning, the two Bradys, and others of whom some are still with us. He botanized, geologized, dredged, collected fossils, and all things—in a universal way almost appalling to a modern specialist. Moreover, in geology he was by no means a mere collector, for he did a considerable amount of original mapping—as in Weardale and in Redesdale—long before the Geological Survey had entered upon the ground. Chiefly in order to be nearer the Museum and the Library of the Literary and Philosophical Society he after a few years removed from Shields to Newcastle, where he opened another private school, in which many of the present leading men of the North were educated—including, I believe, the actual senior Member for the city. When Dr. King left Newcastle Mr. Howse succeeded to the Curatorship of the Museum, still keeping school, however, and devoting only what time he could spare to the collections. But this was for a short period only, and in the seventies he was able to relinquish teaching and give his whole time to the Museum. The removal of the specimens, many of which had scarcely been unpacked before for lack of room, and their entire rearrangement in the Hancock Museum (largely due to the liberality of the late Lord Armstrong, and opened by the Prince of Wales in 1884), were carried out by him with the assistance of his well-known and capable lieutenant, Mr. Joseph Wright. Curating was not his only work: he was *ex-officio* editor of the joint Transactions of the Natural History Society and Field Club, and also for many years one of the Honorary Secretaries of the latter.

Mr. Howse's publications were far too numerous to be fully detailed here. Amongst the most important must be mentioned an admirable Synopsis of the Geology of Northumberland and Durham, written jointly with Mr. Kirkby for the use of the British Association in 1863; a Catalogue of Permian Fossils, with a later Supplement, which gave rise to a lively priority dispute with Dr. King, whose own "Catalogue" appeared almost on the same day as Mr. Howse's; a Catalogue of the Hutton Collection of Fossil Plants; one of the local Carboniferous Fossils in the Museum; another of the Fishes, etc.; and some joint palæontological papers with Albany Hancock and others. Of purely geological memoirs two—one on the Boundary between the Millstone Grit and the Carboniferous Limestone Series and the other on the Divisions of the Drift in the North of England—were of special value.

Mr. Howse's writings on geology and palæontology, however, do not represent a tithe of the results of his labours. He overflowed with information, but was slow to publish. Much of his knowledge has died with him, since he does not appear to have left any manuscript notes of consequence. Many undescribed specimens remain in safe keeping which it had been his intention to describe, and which are still, of course, available for study.

Mr. Howse was essentially a practical and original worker, and a willing helper to other workers. His kindness to all in whom he saw even the slightest trace of the great love of Nature which was his own most striking characteristic was unfailing. Coupled with this was a sensitiveness which sometimes led him into controversies such as that with Professor King already referred to, and a constitutional shyness which prevented him from taking any prominent part on public occasions. It is pleasant to think that notwithstanding this he was gratified towards the close of his active and useful life by the award of an honorary degree by the University of Durham. G. A. Lebour.

JOSEPH LE CONTE.

Born Feb. 26, 1823. Died 1901.

Joseph Le Conte was born in Liberty Co., Georgia, Feb. 26th, 1823. He was a descendant of a French Huguenot who towards the end of the seventeenth century emigrated to New Rochelle, New York. His grandfather removed to Georgia before the revolution. His father, Louis Le Conte, was a graduate of Columbia College. Joseph graduated at Franklin College, Georgia, in 1841, and at the New York College of Physicians and Surgeons in 1845. After practising for a short time at Macon, Georgia, he went to Cambridge, Mass., where he studied under the elder Agassiz, whom he accompanied in 1851 on an exploring expedition to Florida. After graduating at the Lawrence Scientific School in Cambridge he was for a few years Professor of Natural History and Geology in Franklin College, and from 1856 to 1869 Professor of Chemistry and Geology in South Carolina College. In 1869 he was appointed Professor of Geology and Natural History in the University of California, a post that he held from that time until his death. In 1892 he was President of the American Association for the Advancement of Science, the meeting being held that year at Rochester, New York. He wrote a series of papers on Monocular and Binocular Vision, but his more important works deal with Natural History and Geology. In 1874 he issued his book on "Religion and Science: a series of Sunday lectures on the relation of natural and revealed religion," and in 1888 his work on "Evolution: its history, its evidences, and its relations to Religious thought." He published several papers on Physical Geology; of these his essay entitled "A theory of the formation of the great features of the earth's surface" deserves to be specially mentioned. His "Elements of Geology" appeared in 1878, and a revised and enlarged edition in 1882.